ECONOMIC ANALYSIS OF BENEFICIAL MANAGEMENT PRACTICES IN SOUTHERN MANITOBA

A Thesis

Submitted to the College of Graduate Studies and Research

In Partial Fulfillment of the Requirements

For the Degree of Master of Science

In the Department of Agriculture and Resource Economics

University of Saskatchewan

By

Jonathan Mingle

PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a graduate degree from the University of Saskatchewan, I agree that the Libraries of this University may make it freely available for inspection. I further agree that permission for copying of this thesis in any manner, in whole or in part, for scholarly purposes may be granted by the professor or professors who supervised my thesis work or, in their absence, by the Head of the Department or the Dean of the College in which my thesis work was done. It is understood that any copying or publication or use of this thesis/dissertation or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of Saskatchewan in any scholarly use which may be made of any material in my thesis.

Requests for permission to copy or to make other uses of materials in this thesis in whole or part should be addressed to:

Department Head
Department of Agriculture and Resource Economics
University of Saskatchewan
51 Campus Drive
Saskatoon, Saskatchewan
Canada, S7N 5A8

ABSTRACT

Public concern of the value of environment quality has risen over the past three decades and numerous policies, programs and strategic plans have been developed to address damage to the quantity and quality of environmental attributes. The adoption of agricultural beneficial management practices (BMPs) by producers can result in increased environmental benefits and/or decrease the negative environmental impacts from certain agricultural activities. In Canada, farmers have been encouraged to adopt BMPs through government payments that are designed to partially offset the costs of BMP adoption on their land. The purpose of this study is to develop estimates of the social value of environmental improvements caused by the adoption of BMPs by farms in Manitoba.

A contingent valuation method (CVM) is used to estimate the social value of improvements in water clarity, water odour, water quantity (flood reduction), and recreation and fish habitat using two sample population; 1) South Tobacco Creek (STC) watershed area in south western Manitoba, 2) Ag Days Farm show in Brandon, Manitoba. Heckman selection models (Probit and OLS regressions), are used to estimate respondent's willingness to pay for some environmental quality improvements. The results suggest that society ascribes positive value to the selected environmental quality improvements with water quantity (flood reduction) attributed the highest value.

ACKNOWLEDGEMENT

My heartfelt and sincere gratitude goes to my co-supervisors, Professor Kenneth Belcher and Dr. Mohammad Khakbazan for critically examining my scripts and for their constructive suggestions and corrections, and also to my advisory committee members Dr. Jane Elliott and Professor Suren Kulshreshtha, for their participation and for providing me with valuable suggestions throughout in writing of this thesis. My appreciation again goes to Mr. Seth Owusu, Kobby Awuah and Richard Baah for their support and assistance. Special thank you goes to my external Examiner, Dr. Chad Lawley for his insightful contribution to make this thesis a better one.

I would further like to express my gratitude to AAFC for providing me with financial assistance. I also wish to thank all the faculty, staff and graduate students in the Department of Agriculture and Resource Economics for their generous support and encouragement necessary to complete this endeavor.

I would like to thank my family in Ghana for the roles they have played in shaping me as a person. However, without the sacrifices that my mother made, none of my achievements - personal or professional, would have been possible. She is a fighter and my biggest inspiration. I dedicate this thesis to her.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Background

Agriculture practices can have negative impacts on the environment by altering the health and function of associated natural ecosystems (McRae et al., 2000). Some agricultural activities, such as tillage, drainage, intercropping, grazing and extensive usage of pesticides and fertilizers, have been shown to, at times, have significant negative implications for the environment (AARD, 2004). Skinner et al. (1997) report that the environmental impacts of agriculture are often associated with pesticides, nitrogen (N) and phosphorus (P) compounds, farm livestock wastes and soil erosion in production. The detrimental environmental impacts of agricultural practices are costs that are typically unmeasured since they may not influence farmer or societal choices about production methods (Tilman et al., 2002). However, with mounting concern for the environment and increasing environmental legislation, good environmental management has been a policy objective for programs that encourage farmers to adopt beneficial management practices (BMPs) (Hilliard et al., 2002). BMPs are agri-environmental practices which are designed to decrease the impact of agricultural activities on the environment as compared to conventional management practices (AARD, 2004). The United States Environmental Protection Agency (EPA) defined BMPs as schedules of activities which enhance maintenance procedures and other management practices to reduce impact on the environment (EPA, 1998). Agriculture and Agri-Food Canada (AAFC) (2005) also defined BMPs as farming practices designed to minimize negative impacts on the environment.

One of the important objectives for BMP adoption has been to address water pollution caused by agricultural activities. Water pollution, particularly by nutrients and herbicides, has been recognised as a problem since the 1970s (Matthiessen et al., 1992). Goolsby et al. (1993) reported that as much as 15 percent of nitrogen fertilizer and approximately 3 percent of pesticides applied to cropland in the Mississippi River Basin are transported by surface water to the Gulf of Mexico. According to Chambers and Dale (1997), accumulations of nutrients and pesticides in surface and groundwater reduce water quality and can negatively affect the health of aquatic ecosystems and humans. Similarly, excessive runoff loss of P applied in the form of mineral fertilizer or manure may give rise to reduced water quality and eutrophication in downstream water bodies (Sharpley and Rekolainen, 1997). A report by Thomsen et al. (2010) concluded that water quality in Lake Winnipeg deteriorated over time, and in particular, during the past three decades due to enrichment from N and P loadings which are the leading cause of eutrophication. The increased public attention over pollution of water bodies has led to a number of federal, state, provincial and local government organizations to develop policies and programs for improving water quality (Howarth, 2003).The adoption of agricultural BMPs by producers can result in increased environmental benefits and/or mitigate the negative environmental impacts from certain agricultural activities (DUC, 2006). However, pressure to be competitive in the agricultural industry can result in the cultivation of marginally productive lands and wetland drainage, and the greater use of agricultural inputs and chemicals, all of which have negative environmental implications (DUC, 2006).

Different suites of BMPs have been applied in different agricultural areas depending on the primary agricultural practices, climatic condition or the local pollution problems (AAFC, 2004). BMPs have been classified into three general categories: i) input management BMPs that include practices that aim to reduce the availability of an input, such as fertilizer, that could contribute to offsite pollution; ii) transport control BMPs that include practices that attempt to control the movement of available inputs that could be a contaminant and; iii) barriers and buffers BMPs that block or prevent the introduction of contaminants into water bodies once an available contaminant has been included in a transport process (Hilliard et al., 2002). Examples of BMPs that have been developed for Canadian agriculture include, fertilizer/nutrient management, strip cropping, shelterbelts, buffer strips, cover crops, retention of runoff from livestock feeding areas, crop residue management, and conversion of cropland to permanent forage. The Government of Manitoba (2013) has introduced the specific BMP categories of water retention structures, wetland restoration, riparian area, natural area maintenance and management, shelterbelt/tree enhancement, perennial cover for sensitive land and buffer/grassed waterway establishment as critical watershed practices which could increase or improve water quality.

Given the background provided above, agricultural BMPs have been developed and implemented since the 1990s with one of the important goals being to reduce the environmental impact of agricultural activities on ground and surface water quality (Wassenaar et al., 2006). However, BMP-based policy development and adoption is dependent on understanding the effectiveness and efficiency of these management practices based on their ability to meet environmental objectives and the economic performance of the practices. In 2004 the Government of Canada, through AAFC, introduced the Watershed Evaluation of Beneficial Management Practices (WEBs) project which sought to assess the economic and environmental impacts of BMPs. The project was undertaken at nine different watersheds across Canada (Figure 1.1) (AAFC, 2011). The primary objectives of WEBs were to measure the biophysical and hydrological impacts of on-farm BMP adoption as well as evaluating the costs and benefits associated with the BMPs.

Figure 1.1 Watershed sites evaluated as WEBs projects in Canada

In addition to assessing the environmental performances of BMPs, the WEBs project in the province of Manitoba also established a farm level economic analysis and a hydrological modeling framework to characterise water quality benefits and the development of an integrated modeling system to examine the economic and environmental trade-offs of BMPs in the South Tobacco Creek (STC) Watershed (AAFC, 2004). A significant body of economic research has shown that aside from the on-farm benefits attributed to certain BMPs, in many cases their adoption results in off–farm benefits to the public and other users of associated surface water, and sometimes, ground water (Stonehouse, 1997).

1.2 Problem Statement

The development and improvement of BMP policy measures that can decrease environmental risks from agricultural activities requires an understanding of both the internal and external costs of those BMPs. Internal costs and benefits are often recognized by the producers who adopt the BMP while the external cost and benefits are those that flow to individuals and groups outside the farm that has adopted the BMP. This information is also necessary to demonstrate and/or quantify the net benefits of the program to society who are often responsible for supporting these programs through tax revenues, while also informing the allocation of limited program funding amongst BMP projects. Offsite changes such as changes in water quality may affect many stakeholders within a large watershed including those that use downstream surface water for residential, recreational and commercial purposes and therefore requires an estimation of the primary costs of nutrient pollution of lakes and rivers.

Although research has shown that BMP adoption may provide external benefits (or decrease external costs) to downstream water users; there is little work in the scientific literature estimating the value of these downstream benefits (Bertrand, 1999). The purpose of this research is to assess the monetary value of the external benefits of BMP adoption including those benefits associated with water quality improvement and flood mitigation. This research will focus on the STC watershed in south western Manitoba which is part of the larger Red River watershed that drains into Lake Winnipeg. The STC is one of the WEBs watersheds and as such has been the subject of a range of research activities focused on the performance of selected BMPs, particularly with a focus on internal costs and benefits. Moreover, substantial social benefits of BMP adoption including a range of damage control, educational and aesthetic benefits experienced by local watershed residents and recreational users, wildlife and quality of life values experienced by broader regional /national watershed may exist due to farmer BMP adoption. The data available from these WEBs projects will enable the present research to evaluate the related internal and external costs and benefits associated with selected BMP adoption.

1.3 Research Objectives

The primary purpose of this research is to estimate/quantify the monetary value of downstream water quality and quantity changes associated with adoption of a given set of BMPs. The specific research objectives are:

1) To estimate the monetary value of downstream water quality and quantity changes associated with BMP adoption in an agricultural watershed,

2) To compare values of water quality and quantity changes associated with BMP adoption in an agricultural landscape with a more general population, and

3) To quantify the impact of respondent characteristics on environmental values and decisions to support environmental quality improvements.

1.4 Organization of Thesis

The following is an outline of the thesis. Chapter 2 is a synopsis of the literature reviewed for this research. The chapter begins with an overview of the impact of agriculture on the environment and discusses the role of policy to address environmental issues related to agriculture. This chapter also examines types of environmental objectives addressed by BMPs, the types of BMPs and the performance of BMPs as well as a disscussion of the literature examining the role of understanding the private and public value of environmental changes caused by BMPs. Chapter 3 describes the conceptual framework employed in this research. Externality, a cause of market failure is explored using an appropriate model of economic markets and the corresponding theoretical solution is provided to address such failures in the market. Chapter 4 describes the study areas, data collection and methods used to determine the specific external benefits of the BMPs. Chapter 5 presents the results of the economic valuation of the focus BMPs. The econometric model employed is also included in this chapter. Chapter 6 summarizes the research results, presents conclusions about the values of environmental changes associated to BMPs adoption and lists recommendations for improving adoption of the BMPs by farmers. Areas for future research are also provided in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter begins with an overview of the literature examining the impact of agriculture on the environment, and discusses the role of policy to address environmental issues related to agriculture. In addition, overview of the literature on BMPs as a specific type of policy as well as a further discussion of Canadian BMP policy is also provided. The review also includes a detailed discussion of the types of environmental objectives addressed by BMPs, the types of BMPs and the performance of BMPs as well as a disscussion of literature examining the role of private and public value of environmental changes caused by BMPs. Due to the scope of this study, a broad review of the literature was undertaken including program evaluation literature from the federal government, provincial governments, international organizations, peer reviewed journals, as well as academic literature on economic and environment analysis of BMPs

2.2 The Impact of Agriculture on the Environment

Agriculture has changed significantly in terms of production patterns and structure resulting in significant increases in agricultural productivity and net output over the last few decades. This increase in agricultural productivity has been achieved as a result of factors which include increased use of fertilizer and pesticides, and the development and adoption of more technically advanced machinery (e.g. computer monitoring systems, GPS locators, and self-steer machines which increase the precision of input use), development of hybrid strains, and increased knowledge about farm management practices (Lichtenberg, 2000). As agriculture has become more intensive, farmers have become capable of producing higher yields using less labor and less land. However, its impact on the environment through potential degradation of the soil and water resources vital to both farm productivity and human health has become increasingly evident. Tilman et al. (2002) argued that unsustainable agricultural and aquaculture practices present the greatest immediate threat to species and ecosystems. Soil erosion from farmland threatens the productivity of agricultural fields and causes a number of environmental problems elsewhere (Mitchell and Carson, 1984).

Agriculture impacts the environment both positively and negatively and that could be experienced by the producer and society at large. Detrimental impacts on species diversity, habitat-landscape, and the quality of air and water from agricultural pollutants can occur either on or off the farm site (Stonehouse and Bohl, 1990). Herdt and Steiner (1995) point out that the continuous increase in human-made inputs applied in most agroecosystems has increased yields but may be offset by reductions in the quality of the natural capital (e.g. land and water degradation).

2.2.1. Ecosystem Services

Costanza et al. (1997) defined ecosystem services as ‘‘the benefits human populations derive, directly or indirectly, from ecosystem functions’’. In other words, they are benefits through which natural ecosystems sustain human life. In natural ecosystems, soil fertility, for example, is maintained by the diverse contributions and recycling of nutrients by a wide range of plant and animal species (Daily et al., 2000). From society's perspective, ecosystems, such as wetlands, perform a range of functions that arise from the interaction of the structural components (soil, flora, and fauna) and the physical, chemical, and biological processes (De Groot et al., 2000). As outlined by Millennium Ecosystem Assessment (MEA) ecosystem services could be grouped into four major categories: a) Regulating functions b) Supporting functions c) Provisioning functions and d) Cultural functions. Each of these categories is defined by De Groot et al. (2000) as follows:

- Regulating functions - those functions that regulate essential ecological processes and life support systems through biospheric processes. In addition to maintaining ecosystem (and biosphere) health, these regulating functions provide many services that have direct and indirect benefits to humans (such as clean air, water and soil, and biological control services) (De Groot et al., 2000).
- Supporting functions - those functions that provide refuge and reproduction habitat to wild plants and animals and thereby contribute to the (in situ) conservation of biological and genetic diversity and evolutionary processes.
- Provisioning functions - functions related to the capacity of ecosystem processes including photosynthesis and nutrient uptake by autotrophs converting energy, carbon dioxide, water and nutrients into a wide variety of sugars. This function reveals that agriculture manages primarily for provisioning functions
- Cultural functions - natural ecosystems provision of essential reference functions that contribute to the maintenance of human health by providing opportunities for

reflection, spiritual enrichment, recreation and aesthetic experience. (De Groot et al., 2000).

A significant body of studies have reported decline in ecosystem functions (water quality, habitat, and biological process) as the extent of agricultural land use increases (Roth et al., 1996; Sponseller et al., 2001, Wang et al., 2003). Nonpoint inputs of pollutants, destruction of riparian zones, and higher input of pesticides accompanied by increased and intensification of agricultural land use alters the structure and functions of ecosystems (Skinner et al., 1997). Therefore, understanding the contribution of various agricultural practices to the range of ecosystem services would help inform choices about the most beneficial agricultural practices and to establish and maintain sustainable agro-ecosystems. For example, land-cover changes can be used to predict erosion, which are tied to ecosystem services both in terms of water quality and future agricultural productivity (Maloney et al., 2005; Lovell and Sullivan, 2006). Tilman et al. (2002) showed that ecosystem services have been a useful way to characterize agriculture for policy development purposes. These authors indicated that being able to quantify how agriculture can affect ecosystem services is necessary to perform a full accounting of the costs and benefits of agriculture both worldwide and in specific locations. These ecological indicators are useful to address these environmental challenges through agricultural policy development.

2.3 Agri-Environmental Policy and BMPs as a Specific Type of Policy

As discussed earlier, the intensification of agricultural production processes has resulted in pressure on natural resources and the environment. An issue of increasing importance to policymakers is how to address and reduce agriculture impact on the environment. Agri-environmental policies and programs seek to increase environmental benefits and decrease environmental damages associated with agricultural production (Limburg et al., 2002). Agricultural BMPs, as a common form of agri-environmental policy, are often developed by scientists and agronomists in partnership with producers, government, producer groups and conservation associations to address existing environmental issues, reduce overall environmental risk and enhance benefits provided by agriculture (Hilliard and Reedyk, 2003).

Agricultural BMPs play an important role in the conservation of the environment in agricultural landscapes. BMPs include practices and farm operations which can help preserve and restore critical habitats, protect watersheds, and improve soil health and water quality. Stonehouse and Bohl (1990) stated that such practices are designed to decrease the impact of agriculture on natural resources and the environment under agricultural land-use in general. For example, in Florida, agricultural producers were able to reduce their impacts on water quality through the implementation of BMPs delivered by Florida Department of Agriculture and Consumer Services (FDACS, 2007). Implementing BMPs benefits both the farmer and the environment, and demonstrates agriculture's commitment to water resource protection as well as society at large.

2.3.1 Canadian BMP Policy

Over the past three decades, Canadians have made significant commitments toward more sustainable agriculture. This is evident through agri-environmental policy development including a range of policy options developed to harmonize agricultural production with preferences for improved environmental quality (Batie, 1984). In Canada, a set of policy frameworks have been put together to ameliorate agriculture impact on the environment (Limburg et al., 2002). Canada’s current agri-environmental policy framework, Growing Forward 2, is a joint Federal-Provincial-Territorial agreement that includes programming to assist farmers in meeting society’s priorities, including protecting the environment. It also focuses on transformation, competitiveness and market development to ensure Canadian producers and processors have the requisite technical know-how and resources they need to enhance their production and necessary marketing strategies available (AAFC, 2016). Under this agreement there are programs that share the cost of implementing specific BMPs with producers. AAFC (2002) named environmental sustainability as one of the five pillars of reforms in the Canadian Agricultural Policy Framework for the 21st century. Environmental Farm Plans (EFPs), and BMPs, among others, were the main agri-environmental policies introduced. The EFP is a policy instrument that is designed to raise awareness among producers of practices that support and enhance environmental stewardship (Stonehouse, 2000). The AAFC BMPs have been developed as policies and strategies to help Canada’s agriculture meet environmental sustainability goals through gathering and providing information on management practices that have less negative impact on the environment (AAFC, 2005). Within the policy framework a participating producer requires a completed EFP before they are eligible to receive support for BMP adoption. The EFP has been designed to address priority issues that include the potential environmental effects of agriculture on the quality of water resources, soils, air etc. (Government of Manitoba, 2013).

2.4 Types of BMPs

A number of BMPs have been developed to address environmental concerns related to agriculture. Based on the particular environmental need of a specific region, BMPs or a combination of different BMPs have been used to reduce environmental deterioration. AAFC (2005) also reported that different suites of BMPs have been applied in different agricultural areas depending on the primary agricultural practices, climatic condition or the local pollution problems. Moreover, the nine watershed sites which were the WEBs target watersheds across Canada utilized a range of BMPs, required to reduce conditions such as erosion, runoff, and sedimentation into watersheds. BMP management, in general, focused on the following practices across Canada: a) riparian buffer strip enhancement b) land conversion (annual crop to grassland), c) managed livestock access to water, and d) nutrient management (AAFC, 2005). AAFC (2005) established three categories based on the environmental conditions of selected watershed:

(i) Riparian types - Riparian zones play a vital role in soil conservation, biodiversity conservation and influence aquatic health. Riparian zones have been identified as the most diverse, dynamic, and complex biophysical habitats on the terrestrial portion of the earth (Naiman et al., 1993). The riparian zones act as buffers and encompass the stream channel and that portion of the terrestrial landscape from the high water mark towards the uplands where there is much vegetation cover. The riparian area essentially acts as a filter or sink, reducing the input of nutrients and sediment to surface waters from the surrounding watershed (Johnson et al., 1991). BMPs promoted to enhance riparian areas include: exclusion fencing, concentrated stream access areas, grazing management plans and remote (off-stream) watering.

(ii) In field/Edge of field - Another classification of BMP is based on the location of practices in terms of target fields with BMPs established at the edge of field or in field (Dabney, 2003). Edge of field BMPs or buffers are designed to trap sediments/nutrients which are not controlled on the field. This includes grass edges and buffer strips. However, in field BMPs as the name suggests, refers to practices within the field designed primarily to protect soil from being eroded. These include manure management, reduced herbicide use, zero tillage, crop rotation and perennial cover.

(iii) Land/Water Surface Runoff - BMPs which are classified as run off control mechanisms are those which help to mitigate changes to both quantity and quality of water during peak flows. These BMPs are designed to reduce storm water volume, peak flows, and/or nonpoint source pollution through storage, evaporation, infiltration and filtration or biological and chemical actions (Debo and Reese, 2003). These include storm water diversion (farmyard runoff), holding pond (cattle containment runoff), small reservoirs/dams, buffer strips and suites of surface runoff control measures.

2.5 Environmental Objectives Addressed by BMPs

Within agri-environmental policy, BMPs play an important role in addressing environmental issues related to agriculture. However, for the purposes of this review, the emphasis will be on the use of BMPs to protect water resources through the reduction of pollutant loads and concentrations (water quality), and through reduction of discharge (volumetric flow) that causes stream bank over-topping and channel erosion (flood reduction).

2.5.1 BMP and Water Quality

Some agricultural BMPs have been designed to reduce water quality problems associated with agricultural production. There have been several studies that investigated the economic and environmental impacts of different BMPs that may reduce runoff of nutrients and pesticides from agricultural operations into water bodies (e.g. Hamelett and Epp, 1994; Feather and Cooper, 1995; Pease, 1998). However, discussion in this section will focus on BMP adoption to enhance water quality.

Some BMPs are designed to bring discharge levels of a contaminant (e.g. N and P loadings in surface water) into compliance with downstream water quality standards. In agricultural systems, BMPs, such as adoption of zero tillage, and establishment or enhancement of riparian buffer systems, for reducing nonpoint source pollution have been shown to be effective, although the mechanisms by which such benefits are achieved are poorly understood (Bosch et al., 1994). It is believed that certain types of BMPs can improve water quality by limiting leaching and runoff of chemicals and sediments. It is expected that the adoption of

BMPs to control surface runoff, reduce herbicide use, manage manure, and implement crop rotation cycles will improve water quality (Smith et al., 1996). Lubell et al. (2002) reported the use of vegetative filter strips by orchard growers to control irrigation and storm water runoff into waterways. In Oklahoma, Sharpley et al. (1996) reported that a runoff retention pond reduced sediment by more than 80%, with nutrients export dropping by more than 50%. In a study that examined the performance of five BMPs to reduce nutrient loadings in the STC watershed, Li et al. (2011) reported that the examined BMPs reduced nutrient exports. They found that the BMPs reduced total nitrogen and total phosphorus exports in runoff by 41% and 38% respectively and that a forage conversion BMP was more effective in reducing nutrient losses in particle form, whereas grazing restriction BMPs are more likely effective in reducing nutrient losses in the dissolved forms.

2.5.2 BMP and Flood Reduction

Storm water BMP management ponds have been used over the past few decades as an alternative solution for managing storm water in urban areas. These retention ponds are designed to reduce storm water volume, peak flows, and/or nonpoint source pollution through evapotranspiration, infiltration and retention (Debo and Reese, 2003). Water retention is also an appropriate practice in rural areas. Research in STC showed that controlling peak flows and holding back flood waters can be accomplished with a small dam (Yarotski, 1996). This study reported that the 26 dams established in the watershed covered 30% of the STC drainage area, thus controlling the flow in those areas. In more recent work in the STC, Tiessen et al. (2011) reported that each of the dams in the STC was designed to store 20 to 25 mm of runoff from the associated catchment area and that export of sediment, total N and total P were significantly reduced in both snowmelt and rainfall related runoff.

There are a variety of environmental issues that are addressed by BMPs, but for the purposes of this present study, focus is on flood issues. A clear understanding of social valuation of such improvements is necessary and will act as guidance for better policy development in the area of flood mitigation.

2.6 Private and Public Value of Environmental Changes caused by BMPs

Public recognition of the value of environmental change caused by the adoption of BMPs by farmers has risen quickly over the past two decades (Heimlich et al., 1998). One of the keys to understanding the importance of changes in environment and incorporating this in policy decision-making is to establish the link between a given environmental attribute and its goods and services and how these are valued by individuals and society as a whole (Hull et al., 2007). In other words, economic valuation of environmental attributes will act as guidance for better policy provision. Public valuation of ecosystem services is one of the greatest challenges facing ecological and environmental economics today (Parks and Gowdy, 2013). Hull et al., (2007) stated that people's interest to value environment is triggered by the numerous benefits they derive from it. A considerable amount of academic literature has revealed how individuals and the public value environmental changes caused by farmer adoption of BMPs. Brox et al. (1996) reported that in southern Ontario, the willingness to pay (WTP) for residential water quality improvement was \$4.50 month^{-1} household^{-1}. In another study by Brox et al. (2003), survey respondents were willing to pay \$8.29 month^{-1} for changes that would influence a major water quality problem, or \$4.56 month^{-1} for a minor water problem. In a study of the recreational value of water quality improvement, Dupont et al. (2000) found that the social value for improved water quality which affects water based recreational activities was \$28 to \$30 year^{-1} for improved swimming options while improved fishing and boating was valued at between \$14 to \$21 year^{-1}.

A significant body of research has also focused on the valuation of flood control benefits. Shultz and Leitch (2001) estimated annual flood control benefits for restored wetlands within agricultural landscapes of \$3.7 year^{-1}acre^{-1} with 1 foot of storage impoundment and \$5.3 acre^{-1} year^{-1} with 2 feet of storage impoundments. A similar study, Hovde and Leitch (1994) estimated flood control benefit at \$2.5 acre^{-1} year^{-1} of five individual prairie pothole wetlands. Roberts and Leitch (1997) found that the Mud Lake reservoir and wetland complex in the southern end of the Red River Valley in Minnesota contributed to 57 percent of avoided downstream historic flood damage, which was equivalent to a flood mitigation value of \$440 acre^{-1} of reservoir surface area annually. This same study also employed the contingent valuation method to determine that the combined habitat, recreation, and aesthetic values for the wetland complex for household were \$21 acre^{-1} year^{-1}.

2.7 Summary

Agricultural BMPs provide an important range of ecosystem goods and services to society. However, many of these ecosystem goods and services are being undersupplied, or lost due to the inability of markets to efficiently provide the necessary incentives from a social welfare perspective. Thus, policy measures are established to help fill these gaps by balancing the perceived responsibilities and interests held by society and landowners for providing EG&S. Many policy frameworks can be used for different purposes, with different features and implications, and in many situations a combination of them is desired for efficient outcomes. Similarly, many valuation techniques can be used to help in the development of economic incentive policies. This information is important for designing an effective economic incentive policy. The next chapter proposes a theoretical framework to explain market failure through positive externality.

CHAPTER 3
CONCEPTUAL FRAMEWORK

3.1 Introduction

This chapter presents a conceptual framework to help understand the role of economic markets in the provision of environmental attributes and the role of social values in their efficient allocation. In this chapter a market model is developed to interpret the adoption of agricultural BMPs by private landowners within agricultural watersheds. The framework is based on the theory of the consumers' utility problem. The chapter begins with a discussion of how a market failure will result in the under-supply of certain environmental attributes that society values. The role and methods of non-market valuation are then discussed to provide background knowledge of the framework. Finally, a detailed discussion of the theory of demand for environmental quality is presented in order to provide guidance on how to measure social demand and social values.

3.2 Market Failure in Agricultural Production

Market failure occurs when the market fails to allocate resources efficiently (does not maximize total net benefits). Efficiency occurs in a market where all important information is available to all participants at the same time, and where prices respond to available information. Market failure can be caused by a number of factors including externalities, public goods, incomplete property rights, and limited market information. This section focuses on developing the market model and explaining the role of public policies to help address the externality problem.

Externalities occur when one person's actions affect another person's well-being and the loss in welfare is uncompensated (Johnson, 2003). Externalities are often due to incomplete property rights – all of the benefits and costs associated with using a resource are not captured by the holder of the rights (rights are not exclusive). This can also be linked to public goods because of the free rider problem. This occurs when some people who benefit from resource, goods and services do not pay for them because of their non-rivalry and non-excludability nature (Byrne, 2004). Property rights represent "ones individual ability, in expected terms, to consume the goods or the services directly or to consume the goods or services directly or indirectly through exchange" (Barzel, 1997; cited by Whitten, 2003). An efficient use of goods and services is enabled by the existence of well-defined property rights that are held by the decision makers. Byrne (2004) asserts that private ownership prevents/excludes others from using the property because of clearly defined rights which protects the private owner ensuring more efficient management. Absence of clearly defined property right for certain goods and services provided by some practices make it difficult to establish efficient prices in the market (Heimlich et al., 1998). Externalities are normally categorized as positive or negative externalities. Positive externalities occur when an external benefit is generated by the producer of a good but because there is no market for the externality, the producer cannot reap fair compensation for producing this extra benefit. Poterba (1996) indicated that the market price of the good will not reflect its true value in the presence of a positive externality which can lead to an underproduction of the good. Conversely, a negative externality occurs when the consumption or production of a good causes a harmful effect/cost to a third party. In this regard, producers don't take responsibility for external costs that exist – these are passed on to society. Thus producers have lower marginal costs than they would otherwise have and the supply curve is effectively shifted down which results in the market oversupplying those goods that impose external costs.

A graphical model is presented below which develops a basic framework of positive externalities associated with BMP adoption (Figure 3.1). In Figure 3.1, the horizontal axis represents the quantity of output of an agricultural commodity (e.g. tonnes year^{-1}) using a particular type of management. For this model the management is assumed to be consistent with the management used in an agricultural BMP. The vertical axis represents the value of output (e.g. \$ tonne^{-1}) produced using the BMP management - this can include agricultural commodities and other valued outputs. The marginal costs and benefits of the subject management recognized by the manager or farmer are captured by the MC_P and MB_P curves respectively. The MC_P refers to the private marginal costs a farmer incurs when producing commodities using the subject management (BMP management). At each point on the MC_P curve, the farmer will make the decision whether additional production should be added using the BMP management based on the costs they recognize. The MB_P function represents the private (marginal) benefits a farmer will receive from each additional unit of commodity production using this BMP management. Most of these benefits are on-site benefits such as increased farm output, increase income etc. and will be closely linked to the market price of the agricultural commodity produced. Within this market model Q_P represents the privately efficient level of output produced using the BMP style management based on the economic signals the farmer receives as represented by the MCp and MBp functions. In the absence of external benefits provided by BMP management, Q_p is also the socially efficient output.

For the market model in Figure 3.1, I assume that the adoption of the BMP management provides external benefits. MBs represents the social marginal benefit function, such that MBs=MB_p + external benefits. In the presence of these external benefits associated with BMP management there is a market failure such that the privately efficient output (Q_p) is not equal to the socially efficient output, which is designated as Q_s in figure 3.1. At point Q_s the socially optimum output for adopting a BMP management is determined by the point where the MBs is equal to MC_p of adopting the BMP. It can be shown that point Q_s is located to the right of the private optimum quantity (Q_p), indicating uncompensated benefits which are not reflected in the market. In other words, the market undersupplies the environmental benefits associated with the private adoption of BMP management. Since external benefits are not reflected in the market, and moreover, the farmer does not receive compensation for the benefits provided by the BMP adoption, government intervention can be used to address this failure in the market. This is done through efficient compensation (subsidy) that is equal to the external benefit at Q_s (Figure 3.1). Moreover, an information failure concerning these external benefits arises from the difficulty of quantifying most benefits or services from ecosystem, so therefore this gap could be bridged when effective policy measures are implemented (Costanza et al., 1997).

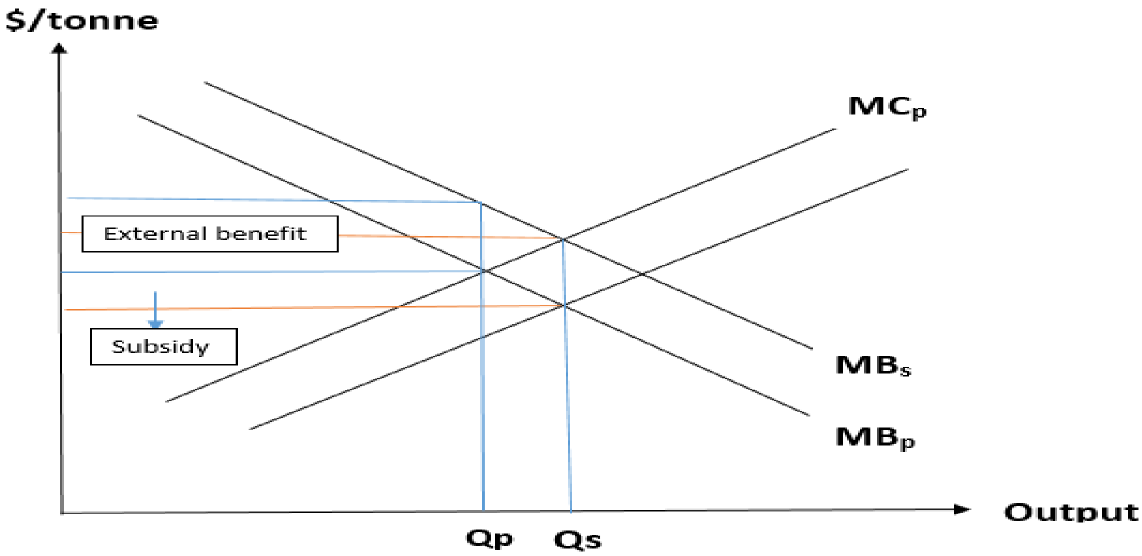


Figure 3.1 An economic market with a positive externality.

3. 3 The Role of Economic Valuation

As demonstrated above, based on the market model, for an allocation of natural resources to be socially efficient the decision makers need to consider the full range of values gained and lost under each resource management option. However, when all values are not considered, such as when there are incomplete property rights and externalities, the private decisions will be inefficient. As highlighted in the model (Figure 3.1), understanding the full range of values (private and social values) under a management which yields an external benefit helps to quantify the true social value for production of a good/service. To include these social values of environmental changes, economics has developed a number of analytical tools to generate estimates of the social values of non-market goods including environmental goods and services. To accurately estimate the social value of a nonmarket good, the value to all stakeholders must be considered (Chambers et al., 1998). The underlying theory of nonmarket valuation is based on two fundamental ideas of neoclassical welfare economics. First, economic value is defined as a measure of its contribution to human well-being, or to the utility of individuals. Secondly that individual's act in their self-interest when faced with alternative incentives (Freeman, 2003). Moreover, non-market valuation has becoming an essential source of information for environmental decision-making since public values about the environment are not generally expressed in the markets.

Chase et al. (1998) indicated two important roles of valuation of nature: firstly valuation can provide information that can directly inform conservation policies, such as payment levels for payments for environmental services (PES) policies, or entrance fees for protected areas; second, and perhaps more importantly, valuation studies can be used in a general sense to demonstrate that the conservation of nature can result in economic benefits to people and improvements in social welfare. The concept of total economic value (TEV) provides an analytical framework to comprehensively evaluate natural and environmental resources. Estimating the value of various services and benefits that are generated by ecosystems may be done with a variety of valuation approaches. However, three different categories of approaches have been widely used to develop valuation methodology: a) revealed preference approaches b) imputed values and (c) stated preferences approaches (Chee, 2004). A brief overview of each of these techniques will be provided.

Revealed preference approaches are based on the observation of individual choices in existing markets that are related to some aspect of the environmental attribute in question. In this regard it is said that economic agents "reveal" their preferences through their choices.

Examples include hedonic pricing, travel cost and production factor method (Osbandi and Green, 1991; Blundell, 2005). The imputed value approach involves quantifying the value of an ecosystem service which is viewed as the cost of replacing that service by some alternative or technological means and includes, for example, the replacement cost method (RCM) (Bockstael et al., 2000). A stated preference approach uses a survey, often involving hypothetical market scenarios, to gather individual perceived value data that can be used to estimate both use and non-use values for environmental quality and quantity (Shultz et al., 1998). Despite their prominence in environmental economics, these economic valuation approaches face serious limitations. First, validity of stated preference data is often questioned because of hypothetical bias (Hausman, 2012). A typical example of a valuation technique based on stated preferences is the CVM (Cummings and Taylor, 1999). The aim is to see how people respond to a range of choices, and thus to establish the extent of collective WTP for a particular benefit (Chase et al., 1998).

3.3.1 Contingent Valuation Method

The CVM is a survey based method that uses a questionnaire to estimate values that people ascribe to goods and services based on their responses to specific questions about the environment or changes in environmental quality and/or quantity (Swinton et al., 2007). This is achieved when respondents state their perceived value by eliciting a maximum WTP for environmental goods and services or other public goods presented to them in a hypothetical market with a proposed or contingent improvement (Shultz et al., 1998). The CVM is the most widely used method for non-marketed goods and services when revealed preference methods are not appropriate (Shultz et al., 1998). When considering why individuals place values on a natural resource, Freeman (2003) distinguished between those who use the resource (services) and those who do not. Users are persons who make direct or indirect use of the good while non-users are persons who are willing to pay for the change in the provision of the good but who make no direct use of the good. Unlike revealed preference methods, CVM provides estimates of use and non-use values. Debate over the methodology, implementation, and practical application of CVM continues, and resulting improvements have contributed to the robustness of CVM results.

3.4 Summary

External benefits that occur within an agriculture landscape can be associated with market failures that are often caused by the public good nature of such benefits. To address the problem, government intervention can be employed including the introduction of monetary incentives to encourage the adoption of the management practices that generate the external benefits (i.e. improvement in environmental quality). To inform the development of these economic incentives there needs to be information on the social value of the external benefits. In order to efficiently measure the value of external benefits, non-market valuation techniques can be applied. The values are estimates of society's WTP for environmental changes which could be associated with BMP adoption. Information on values could be used as a guide for the allocation of incentives to encourage the adoption of these BMPs.

CHAPTER 4

STUDY AREA AND METHODS

4.1 Introduction

Government policies can be used to provide incentives to farmers to increase their provision of environmental attributes to increase social welfare. Developing such policies requires an understanding of society's perspective, and valuation of environmental attributes. Based on the theoretical framework presented in Chapter 3, this chapter will develop a specific case study to estimate the monetary value of environmental attributes to society within an agricultural landscape by applying stated preference methods. This chapter begins with a brief description of the study area followed by a detailed presentation of the survey methods, instruments and procedures used.

4.2 Study Area

The STC watershed is located at the edge of the Manitoba Escarpment near Miami, Manitoba. South Tobacco Creek flows west to east into the Red River via the Morris River (Figure 4.1; Figure 4.2). The watershed receives 570 mm of annual precipitation, 25% of which is snowfall (AAFC, 2008). The soil consists mainly of clay loams formed on glacial till with overlaying shale bedrock giving the soils characteristics that are productive for crop production with fairly high water holding capacity, moderate infiltration and limited risk of groundwater impacts from leaching (Michalyna et al., 1988). The STC watershed drains 7,638 ha of which 71% (5,409 ha) is under cultivation in a total of 333 individual fields (Hope et al., 2002).

Land use within the STC watershed is primarily agricultural, with the majority of the land under annual cropping, and the main source of income for many inhabitants (AAFC, 2004). Intensive agriculture in the STC has contributed to water quality and biodiversity issues in the watershed as well as within the downstream rivers and lakes including the Red River and Lake Winnipeg. The STC was developed by AAFC as one of nine experimental WEBs sites across Canada. The WEBs project sought to assess the economic and environmental impacts of BMPs.

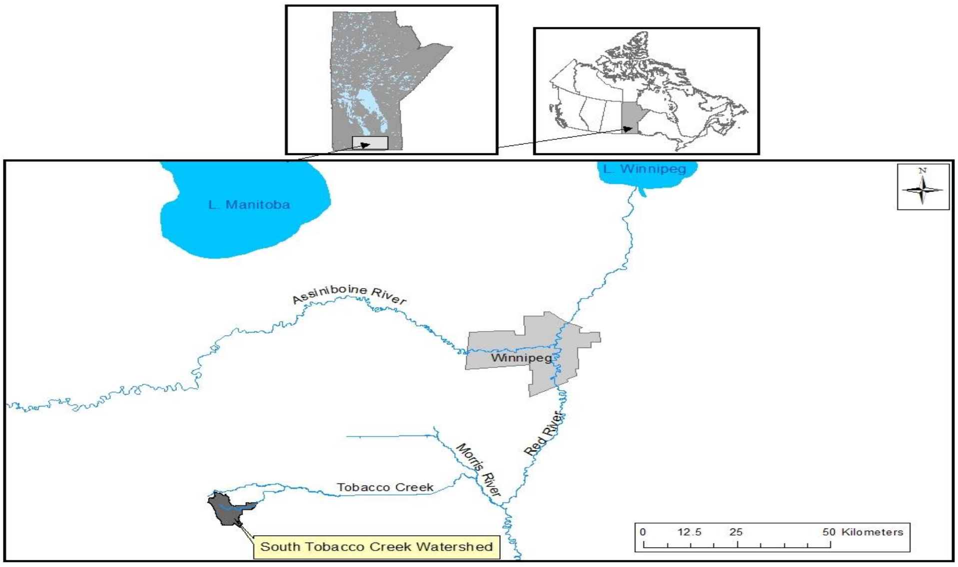


Figure 4.1: Map showing lakes and STC watershed in Manitoba

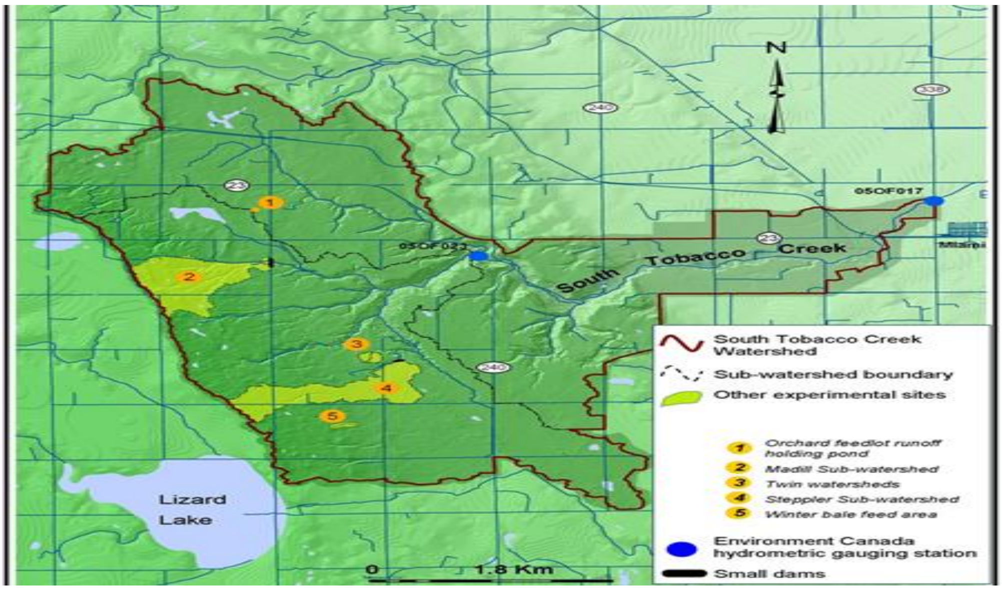


Figure 4.2 Map of South Tobacco Creek Watershed, Manitoba. Adapted (AAFC, 2004)

The BMPs included in the STC assessment were winter bale-grazing, holding ponds downstream of winter cattle containment areas, comparison of conservation and conventional tillage, conversion of annual cropland to perennial forage and small dams and reservoirs (AAFC, 2004). Between 1985 and 1996, a network of 50 small-scale headwater retention dams was constructed to prevent peak water flows during excessive rainfall and snow melt. Of these dams, 26 directly impact on water management in the STC watershed by controlling the drainage of the area and thus reducing overall peak flows in the basin by up to 25 percent (Yarotski, 1996). High intensity run-off downstream of individual dams has also been reduced by as much as 90 percent (Deerwood Soil and Water Management Association, 2000). The STC watershed was selected for my study because of the long history of biophysical research in the area. This facilitates a more complete research program focused on the impacts and values of BMPs.

4.3 Survey Instrument

To estimate the social value of changes in environmental quality attributable to the adoption of BMPs in the study area a CVM survey instrument was developed. The questions in the survey were developed based on previous research and expert inputs and designed to elicit values of some selected environmental attributes. The survey package included a consent form and an initial letter of contact (Appendix A) explaining the purpose of the survey and participation rules as well as the main section of the survey comprised of a questionnaire. The initial letter of contact provided potential respondents a brief background to the study. The consent form contained information which ensured that each respondent understood the survey and the implications and risks associated with completing the survey. The consent form also briefly introduced the researchers and stated the study purpose and procedure, potential benefits and risks, how the data will be stored and the commitment from the researchers to maintain confidentiality of any particular information that is not of public interest. Participants were also given an option to withdraw from the study for any reason, at any time during the survey process, without penalty of any sort.

4.3.1 Survey Questionnaire

The survey consisted of a background and 4 sections and was expected to be completed by respondents in 10 minutes. The survey questionnaire was developed to elicit values from two sample populations, 1) residents of the STC watershed and, 2) a more general segment of the Manitoba population. The background provided the respondent with a brief description of types, cost and benefits of BMPs. This was provided to help respondents understand what BMPs are, costs incurred in adopting these BMPs and benefits that may arises when farms adopted various kinds of BMPs. Section one of the questionnaire included a number of questions about the respondent characteristics, their knowledge about BMPs and a definition of the environmental attributes the researchers wanted them to evaluate. As suggested by

Champ et al. (1997), the information provided about the environmental attributes that were the focus of the questions increased the incentive for participant to answer genuinely. To reduce ambiguities and ensure survey language could be easily understood by respondents, the survey scenarios were clearly stated and interpreted so as to enable them to answer questions as they were originally intended (a copy of the survey is included as Appendix B). To minimize hypothetical bias from cheap talk responses, I employed the measure of confidence in responses as presented in section three of the survey.

The specific environmental attributes that were the focus of the valuation instrument were presented in section two of the survey. This section was comprised of eight valuation questions focused on four different environmental quality attributes, which will be described in detail later in this chapter. Section three focused on measuring the perceived level of confidence of the respondent about their answers. This was necessary as level of confidence about an answer could be used to adjust the values of environmental attributes that were estimated (Bishop, 1999). Finally, section 4 was developed to collect demographic information of the respondent. This information could be used to evaluate heterogeneity in preferences as well as helping to quantify the comparison between the two sample populations.

4.3.1.1 Attributes Description and Payment Card

Respondents were presented with a range of environmental characteristics related to surface water quality and quantity that could be influenced by the adoption of BMPs upstream in a watershed. The four identified and defined environmental characteristics were presented to the respondents at different levels of quality and/or quantity to enable the responses to measure their perceived values related to these changes in environmental quality in the local creeks and rivers. The four environmental attributes pertaining to Manitoba watersheds were identified in consultation with an environmental scientist and an agricultural and an environmental economist at the University of Saskatchewan (Professor Kenneth Belcher and Dr. Jane Elliott). Water clarity, water odour, water quantity and recreation and fish habitat represent separable dimensions of the valuation problem and are attributes that can partially describe the outcomes of alternative water quality and quantity management strategies that are of importance to the local policy makers and the community. While a large number of environmental attributes and levels of quality could be relevant in the study areas, for the purposes of the present study four attributes with three different levels were selected to prevent fatigue during the filling of survey (Train, 2002). The levels of each attribute used in the CVM survey (Table 4.1) were based on consultation with economic valuation experts from the WEBs projects, University of Saskatchewan and Environment Canada. The survey instrument provided each participant with information on current, or status quo, environmental quality and historical changes in water clarity, water odour, a summary of stages of water quantity and forms of recreation activities possible.

Table 4.1 Environmental attributes and levels used to construct WTP

Attribute	Levels
Water Clarity (WC)	Very murky (cannot see submerged objects)
	Moderately clear (can see objects up to 2 inches under water)
	Clear (can see objects 12 inches under water)
Water Odour (WO)	Odour throughout the ice-free season
	Odour during July and August only
	No odour
Water Quantity (WQ)	Flooding occurs every 1.5 years
	Flood discharge occurring every 5 years
	Flood discharge occurring once every 10 years
Recreation & Fish Habitat (RF)	Limited recreation activity, fishing not recommended
	Fishing possible
	All recreation allowed with high quality

Water clarity: the concept of "turbidity” is often used to describe water clarity (Austin, 1973). Turbidity is a measure of the amount of particulates suspended in water (e.g. sand, silt and algal cells). The more suspended particulates there are in the water, the cloudier it is and, the higher is the turbidity level and the lower the clarity of the water. In other words, suspended sediments, along with the other main light-attenuating constituents, such as dissolved organic matter and water itself, reduce the amount of light illuminating submerged objects (Kirk, 1994). Other things being equal, waters of high clarity are more aesthetically attractive and more valued for use than waters of low visual clarity (Smith et al., 1991; Smith and Davies-Colley, 1992). The water clarity levels used for this attribute and their interpretation included in the questionnaire are:

- Very murky (cannot see submerged objects)
- Moderately clear (can see objects up to 2 inches under water)
- Clear (can see objects 12 inches under water)

Water Odour: There are a variety of defined odour types including earthy, musty, chemical, and chlorine odour (Hoehn, 2002). Odour in water may arise from industrial and municipal sewage or from biological activities of algae and heterotrophic micro-organisms (Hrudey et al., 1992). Some species of algae and bacteria naturally produce odorous chemicals inside their cells. When large numbers of algae and bacteria flourish in a water body (an "algae bloom"), taste and odour-compound concentrations increase to levels above this threshold and cause odour problems (Hoehn, 2002). Increased odour in a surface water body will decrease the perceived quality of the water and therefore the value ascribed to that water. The water odour levels used for this attribute and their interpretation included in the questionnaire are:

- Odour throughout the ice-free season
- Odour during July and August only
- No odour

Water Quantity (Flood Reduction): Flood frequency level is described generally as the abundance/ overflowing of water onto land that is usually dry. Floods occur when ponds, lakes, riverbeds, soil, and vegetation cannot absorb all the water. Water then runs off the land in quantities that cannot be carried within stream channels or retained in natural ponds, lakes, and man-made reservoirs resulting in flooding. Many ecosystem valuation studies consider flood reduction benefits as an attribute or endpoint due to it being a relatively obvious landscape feature that is linked to ecosystem function (Berrens et al., 1996; Tiessen et al., 2010). The water quantity levels used for this attribute and their interpretation included in the questionnaire are:

- Flooding occurs every 1.5 year
- Flood discharge occurring every 5 years
- Flood discharge occurring once every 10 years

Recreation and Fish Habitat: Recreation and Fish Habitat is described in more general term as the accessibility to recreation activities and increased fish population (Birol et al., 2006). Fish population can be deemed a measure when considering larger species valued for recreational observation or fishing purposes. The abundance of fishes and other wildlife population has been identified as an attribute in environmental valuation studies (Carlsson et al., 2003). In more general terms, fishing populations have also been considered building blocks of biodiversity and river recreation (Birol et al., 2006). The recreation and fish habitat levels used for this attribute and their interpretation included in the questionnaire are:

- Limited recreation activity and fishing not recommended
- Fishing possible
- All recreation allowed with high quality

The valuation questions focused on the perceived value associated with increasing environmental quality highlighted in Table 4.2

Table 4.2 Environmental Quality Changes

Environmental quality changes	Abbreviation
Water clarity - murky to moderately clear	WC1
Water clarity - moderately clear to clear	WC2
Water odour - odour throughout the ice-free season to Odour during July and August only	WO1
Water odour - odour during July and August only to No odour	WO2
Water quantity - flooding occurs every 1.5 years to flood discharge occurring every 5 years	WQ1
Water quantity - flood discharge occurring every 5 years to flood discharge occurring every 10 years	WQ2
Recreation and Fish - limited recreation activity, fishing not recommended to Fishing possible	RF1
Recreation and Fish - Fishing possible to all recreation allowed with high quality	RF2

A wide range of CVM techniques have been used to elicit values of environmental attributes. Boyle and Bishop (1988) compared CVM techniques such as dichotomous choice, iterative bidding and payment cards (PC) method to show that each method has its strengths and weaknesses. For example, a single dichotomous choice format presents a “yes or no” choice at an offered price to the respondent (Bishop and Heberlein, 1979). A commonly used extension of the dichotomous choice format includes multiple price lists, iterative bidding and PC. With multiple price list formats, the respondent is presented with an array of ordered prices in a table with one price per row. Each respondent is asked to indicate “yes” or “no” for each price (Holt and Laury, 2002; Anderson et al., 2006). Iterative bidding in a WTP framework starts with the respondent being offered an initial bid, and if the respondent is not willing to pay the initial bid, the bid is revised downward incrementally until a zero WTP bid is provided. The PC method is a technique introduced by Mitchell and Carson (1981, 1984) to address the starting point bias of iterative bidding. Starting point bias occurs when an interviewer suggests the first bid and this can influence the respondents answer and cause the respondent to agree too readily with bids in the vicinity of the initial bid (Mitchell and Carson, 1984). In this study, I used the multiple bounded payment card which allows for respondent uncertainty about payment without having to rely on follow-up questions explicitly designed to measure the degree of that uncertainty. The PC method is data-intensive to design and often suitable for in-person surveys. In the context of the present study the PC approach was used to address the objective of achieving the best approximation of the true perceived monetary value of changes in the quality or quantity of environmental attributes by inducing respondents to reveal their WTP. In other words, respondents were first asked to respond to the highest bid level (greater than $100 per year) then they were asked to each consecutively lower bid level. However, actual WTP is determined where individuals switch from ‘probably pay’ to ‘definitely pay’ (Loomis and Ekstrand, 1997).

In the study questionnaire respondents were presented with a sequence of 12 WTP bids ranging from “greater than “$100 per year” to “$0 per year”, explained as an increase in annual taxes to provide funding for farmers to adoption of BMPs within the watershed. For each WTP bid level respondents were asked to indicate whether they would definitely not pay, probably not pay, probably pay or definitely pay the increase in taxes. An example of the payment cards used to estimate the value of improvements in water clarity from murky to moderately clear and moderately clear to clear is provided in Table 4.3. The respondent WTP for each environmental attribute were determined as the bid level where respondent indicated they will definitely pay. Therefore the amount where the respondent ticks “definitely pay” becomes the maximum WTP for the environmental improvement. The payment cards used to estimate the value of the other environmental attributes (water odour, water quantity and recreation) and levels are provided in the complete survey which is included in Appendix B.

After the respondent completed the eight payment cards representing two changes in quality for each of the four environmental attributes, a follow up question was asked to estimate the respondent’s confidence levels in their WTP values provided in the previous section. This information could be used to correct respondents’ responses to true WTP value by the percent confidence level (Bishop, 1999). The reported confidence levels were used to qualify the values that I calculated. For example if respondents had very low confidence in their water clarity values I would interpret the WTP values calculated as being not strongly representative

Table 4.3 Payment cards used to elicit WTP for environmental improvements

How would you feel about the following proposed increase in annual taxes to increase water clarity from **murky to moderately clear**?

Amount $ Year^{-1}	Definitely not pay	Probably not pay	Probably pay	Definitely pay
greater than100				
100				
90				
80				
70				
60				
50				
40				
30				
20				
10				
0				

How would you feel about the following proposed increase in annual taxes to increase water clarity from **moderately clear to clear**?

Amount $ Year^{-1}	Definitely not pay	Probably not pay	Probably pay	Definitely pay
greater than100				
100				
90				
80				
70				
60				
50				
40				
30				
20				
10				
0				

The question was framed as follows:

"Consider your responses to the previous 8 questions. Are you satisfied that the response you gave accurately reflects your attitudes about changes in water quality and quantity. In the following questions indicate how sure you are about your response to each of the previous 8 questions using a 100 point scale, where 100 indicate you are most sure about your response and 0 indicates you are least sure about your response."

Water clarity

0	10	20	30	40	50	60	70	80	90	100

If you are not sure at all, please indicate why?

....

4.3.1.2. Respondents Demographics

Socioeconomic and demographic profiles of respondents have been shown in other related research to be important for investigating heterogeneity in preferences and explaining consumer attitudes toward, support for, and involvement in environmental protection and conservation issues (Dillman and Christenson, 1972; Schwepker and Cornwell, 1991). The variables chosen in the demographic section for this study are gender, age, education level, home area and income. These demographic categories are commonly included in a majority of studies employing surveys. This data enabled a statistical assessment of the influence that gender, age, education level, home area and income have on a respondent's WTP for a change in environmental quality. These demographics feature were used as explanatory variables in estimation of WTP for improved environmental attributes by a respondent.

4.4 Survey Delivery

Two sample populations were surveyed. The first sample population consisted entirely of residents of the STC watershed with the survey being conducted in March, 2016 (STC sample population). The second sample population represented a more general rural Manitoba population and consisted of attendees at a large farm show (Ag Days in Brandon, Manitoba) in Western Manitoba in January, 2016 (Ag Days sample population). Respondents from STC study area were chosen using a selective sampling method, which is made up of farmers from Deerwood Soil and Water Management Association under the STC project. The sample is biased since farmers may have a strategic incentive to state higher WTP to encourage higher payments from government. However, I compared the STC sample to Ag Days sample to examine the similarities in their payments. Respondents from Ag Days were randomly selected during the Ag Days farm show and asked to voluntarily complete the survey.

4.5 Data Analysis

All descriptive statistics generated for the survey sample populations and calculations of valuation distributions were completed using the Excel 10® software package (Brown, 2001). To determine the effect that respondent demographic characteristics had on WTP estimates for environmental improvements, the R® econometric software (Courtney and Courtney, 2013) was employed. Most of the demographic information was included in the regressions as dummy variables. For example, considering the household income or education information collected in the survey, it is possible to investigate if high income or educated participants have different attitudes towards environmental services (Danso-Abbeam et al., 2014).

For the first part of the data analysis, mean WTP values for individual attributes were calculated using bid amounts at the “definitely pay” response level for both STC and Ag Days sample populations. Thereafter a weighted average was calculated by combining STC and Ag Days averages to obtain social values for environmental improvements under investigation. Secondly, analysis was based on the Heckman selection model using the R® software statistics. The selection of explanatory variables for the regression model is discussed later in section 5.5.2. Both probit and OLS models were used to develop the sample WTP estimates. The coefficient of the probit model require some specific explanation of marginal effects to interpret while the ordinary least squares (OLS) model estimated coefficient can be interpreted as marginal effects (Greene, 2003). Interaction and/or relationship between two explanatory variables were calculated to ascertain their effect in influencing WTP.

4.5.1 Econometric Model

An econometric model was developed to provide a detailed examination of different respondents’ characteristics that impact their decision to financially support environmental improvements. As discussed earlier, a stated preference method (CVM) was used to elicit respondents WTP values through multiple bounded payment cards. The Econometric model was used to establish a relationship between WTP values and personal characteristics based on data collected. The Heckman Selection model was the main econometric model employed for estimating how personal characteristics influence decision to pay for changes in environmental quality of the four environmental attributes, in the two study sites. The Heckman’s selection approach is much easier to implement than other maximum likelihood estimators (MLE), because it represents an efficient method to deal with selectivity in microeconomic applications

(Vella, 1998). Leung and Yu (2000) stated that if no collinearity problems arise, Heckman's procedure may in practice turnout to be more efficient than other MLE. For the present study, there are two dependent variables. One is represented by a dummy variable (probit model) and the other is a continuous variable (OLS model). Alberini et al. (2003) also used two dummies variables of fail to accept (coded as 0) (probably pay" "probably not pay" and "definitely not pay") and accept (coded as 1) ("definitely pay"). The Heckman model is a two stage regression model. First, the conditional expected value of WTP is specified as:

$E\ (Y_{1i}|Y2_i=1) = x_i\beta+\rho\sigma\lambda\ (z_i\gamma)$ …………………………………………………… (4.1)

Where, $\lambda\ (z_i\gamma) = \varphi\ (z_i\gamma)/\ (z_i\gamma)$

E is expected

Yi is the dependent variable, which indicates payment (Y_{1i} = 1 if the respondent is WTP and Y_{2i} = 0 otherwise)

x_i is a vector of explanatory variables,

β is the coefficient parameters,

ρ is the correlation between two outcomes

σ standard deviation

γ omitted variable bias

φ cumulative distribution function of standard normal distribution

z vector of unknown parameters

λ is defined as the inverse Mills ratio.

The first step of the Heckman's procedure is the estimation of the participation equation using the binary probit model, which gives us an estimate of the inverse Mills ratio (λ). In this case λ is the ratio of the probability density function over the cumulative distribution function of a distribution. The inverse Mills ratio is calculated from the probit equation which accounts for zero WTP values. The probit model which represents the binary decision by the respondent of whether to make a payment or not to support (e.g. choice of definitely pay or probably pay, probably not pay or definitely not pay) an improvement in quality of the identified environmental attribute. The second step of the Heckman's procedure consists of an OLS regression (for positive outcome or those who will definitely pay) of Y_{1l} on x and λ (Leung and Yu, 2000). This regression provides estimates of the impact of respondents' characteristics to the magnitude of the WTP bid for the specific improvement in the environmental attributes.

The model was developed based on the assumption that valuation of environmental attributes was influenced by respondents' characteristics including age, income, home area, gender and educational level. The sign of the coefficients in the model indicates the influence of the specific respondent attributes on their WTP for improved environmental attributes and on the magnitude of the payment.

4.5.2 Explanatory Variables

The dependent variables used in the econometric models are i) the decision of whether or not to pay for the improvement in environmental quality and ii) the level of WTP value ($ year^{-1}) the individual indicated they would definitely not pay, probably not pay, probably pay, definitely pay in the elicitation process. Since two different regressions were generated, two dependent variables are defined. WTP is the dependent variable for the probit equation and represents willingness to support or not to support an environmental improvement. The magnitude of the WTP bid is the dependent variable for the OLS model which accounted for the missing values by the inclusion of inverse Mills ratio. Within the model participants are assumed to be heterogeneous agents in terms of their utility, perception and preferences. In the literature, a broad range of factors have been found to inform consumers WTP. A significant body of research has examined the effects of socioeconomic variables on WTP for improved environmental quality (Ali, 2013; Danso-Abbeam et al., 2014). Based on this theory the demographic characteristics of the sample population individuals influence their private value or benefit related to the supply of environmental services (ES) through the adoption of BMPs by farmers within the watershed. As discussed earlier, the mean WTP reflects respondents' value for certain improvement in defined environmental quality.

The variables chosen in the demographic section for this study (gender, age, education level, home area and income) have been included in most studies employing surveys. Within the model, age is represented as four dummy variables with 18-24 years age category as a reference category (Table 4.4). This structure enabled comparative analysis using the present research findings and the appropriate census data. Gender is represented in the model as dummy variables for male and female respondents. Home area is represented in the model by three dummy variables with farm as the reference category. Education level is included to examine its influence on decision to support environmental improvements. It is represented by five dummy variables with some formal schooling as a reference category. Income is also represented by five dummy variables with less than $25,000 as the reference category.

Table 4.4 Variables used in econometric model

Variables	Variable Description
Age	Age of respondent (years) 1 = 18-24 years; 2 = 25-44 years; 3 = 45-60 years; 4 = above 60 years.
Gender	1 = Male, 2 = Female
Home area	Residence of respondent 1 = farm; 2 = rural resident; 3 = urban resident
Education	Completed education 1 = Some formal schooling; 2 = High School diploma or GED; 3 = Some college; 4 = 2 year university or college degree; 5 = 4 year university degree
Household Income $CDN/year	1 = <$24,999; 2 = $25,000-$49,999; 3 = $50,000-$74,999; 4 = $75,000-$99999, 5 = $100,000 or more

4.6 Weighted Mean of WTP

The concept of economic value of environmental changes can be a useful guide or tool when distinguishing and measuring where trade-offs between society and the rest of nature are possible and where they can be made to enhance human welfare in a sustainable manner. This section explains the methods used to develop the analysis and interpretation of the WTP value from the two sample populations. This was achieved by combining the STC and Ag Days sample population using the weighted average method to produce social values for individual environmental attributes representing both sample populations. Specifically this section describes an approach to combine the WTP data from the two sample populations, despite the differences in their characteristics, to develop a more policy relevant measure of WTP for Manitoba residents. Weighted mean was computed using equation 4.2 (Strutz, 2010).

$$Xw = \frac{w_1X_1+w_2X_2+w_3X_3 \ldots\ldots\ldots + w_nX_n}{w_1+w_2+w_3+\cdots w_n} \ldots\ldots\ldots\ldots\ldots\ldots (4.2)$$

Where X_w is the weighted mean of a set of numbers X_1, X_2, X_3 and ….X_n with their corresponding weights w_1, w_2 ,w_3 …w_n. In my calculations X_1, X_2, X_3….X_n are the individual mean WTP values for environmental changes and w_1, w_2, w_3,…….w_n are the weight of individual samples in the entire population. The weighted mean WTP is computed using X_1

and X_2 as mean WTP for an environmental improvement from two sample populations. The weights w_1 and w_2 are the respective sample sizes out of the entire population samples.

4.7 Summary

This chapter has provided the methodology used to address the primary research problem and the specific research objectives. This included a description of the primary study site, the STC watershed located in Manitoba, and introduced that the study area was adopted as one of the sites for the assessment of performance of some BMPs. The utility theory through WTP approach was employed for estimating the social values of the specific improvements in environmental quality. Methods employed to estimate these values were through a CVM survey using a payment card. WTP is applied as a tool to estimate individual's stated preference for certain environmental improvements. In the next chapter, the survey results and an explanation of the factors that may influence the WTP for environmental quality improvements will be discussed.

CHAPTER 5
RESULTS AND DISSCUSSIONS

5.1 Introduction

The previous chapters have provided the theoretical foundations and the methods used to estimate the monetary values of environmental changes to individuals and communities that are in close proximity to the agricultural areas where the BMPs have been adopted. This chapter focuses on presenting and interpreting the findings of this study which will inform policy decisions related to agricultural BMPs that can contribute to environmental quality. This chapter begins with an explanation of the survey results providing descriptive statistics of the sample populations. Analysis of the distribution of valuation responses is also presented in this chapter. The value that the sample population attributes to the environmental changes is presented as WTP. Following this, an econometric model was estimated to evaluate how personal respondent characteristics influence societal participation and/or WTP amounts for each environmental attribute. The implications of these results towards BMP policy development and implementation are also be discussed in this chapter.

5.2 Demographic Results

A total of 82 surveys were completed through face to face interviews during the period of January to March 2016. Thirty surveys were completed for the STC respondents whose residence was located within, or adjacent, to the STC watershed. The remaining 52 surveys were completed by participants during the Ag Days. Overall there were some distinct differences in demographic characteristics between the STC and Ag Days sample populations (Table 5.1). Slightly more than half of the respondents (53.5%) in the Ag Days sample population were between 25-44 years old while in the STC sample population, 60% of the respondents were in the 45-60 year age category. In addition, the STC sample population were primarily (70%) farmers while the Ag Days sample population were primarily (69.2%) urban residents.

Table 5.1 Characteristics of survey respondents from the STC (n=30) and Ag Days (n=52) sample populations and the Manitoba provincial comparison data

Demographics	STC[z] %(frequency)	Ag Days[y] %(frequency)	Manitoba[x] %
Age			
18-24 years	N/A	15.4 (8)	14.4
25-44 years	13.3 (4)	53.5 (28)	26.1
45-59 years	60.0 (18)	30.8 (16)	21.1
60 years and above	26.7 (8)	N/A	38.3
Gender			
Male	70.0 (21)	69.2 (36)	49.0
Female	30.0 (9)	30.8 (16)	51.0
Home Area			
Farm	70.0 (21)	11.5 (6)	10.0
Rural Resident	20.0 (6)	17.3 (9)	18.0
Urban Resident	10.0 (3)	71.2 (36)	72.0
Education			
Some formal schooling	10.0 (3)	-	30.2
High School diploma or GED	6.7 (2)	15.4 (8)	19.7
Some college	30.0 (9)	7.70 (4)	8.3
2 year university or college degree	10.0 (3)	13.5 (7)	30.9
4 year university degree	43.3 (13)	63.5 (33)	20.9
Income			
≤$24,999	13.3 (4)	5.8 (3)	29.1
$25,000-$49,999	33.3 (10)	17.3 (9)	41.2
$50,000-$74,999	26.7 (8)	21.2 (11)	19.8
$75,000-$99,999	10.0 (3)	21.2 (11)	7.4
≥$100,000	16.7 (5)	34.6 (18)	2.5

Source: Survey results, 2016
[z] STC is South Tobacco Creek Watershed in Manitoba
[y] Ag Days Farm Show, Brandon MB
[x] Statistics Canada, 2011 Census of Population

Demographic characteristics of the sample populations were compared with similar indicators from the province of Manitoba 2011 population census to assess the consistency of the sample population with the provincial statistics (Statistics Canada, 2016) (Table 5.1). Age, gender, income and education levels for the STC sample population were different from the provincial population. The difference between the Ag Days sample population and the Manitoba age, gender, income and education data were evident with the exception of home area which seemed quite similar. The STC sample population was not representative of the provincial population based on a comparison of demographic data with 2011 Canada census data for the province. An attempt was made to compare parameters of the STC and Ag Days samples with the parameters of population in western region of Manitoba; however, more directly comparable western Manitoba census data was not available. These results suggest a sample bias in the survey data and therefore not a true representation of the Manitoba population which limits my ability to make generalizations from the sample population findings to the general provincial population.

5.3 Valuation Responses

Respondents were requested to state what they would be willing to pay for a specified increase in each of the 4 environmental quality attributes based on different bid levels in the multiple bounded payment card: 1) water clarity, 2) water odour, 3) water quantity, and 4) recreation and fish habitat. The valuation questions focused on respondent WTP for i) an increase in quality from a relatively low level to a moderate level, and ii) an increase in quality from a moderate level to a relatively high level. Using the multiple bounded payment card respondents were first asked to respond to the highest bid level (greater than $100 per year) then they were asked to respond to each consecutively lower bid level. Using this technique the actual individual WTP will be between the bids that they would be willing to 'probably pay' and the bid that they would be willing to 'definitely pay'. This is similar to the multiple bounded format of PC employed by Loomis and Ekstrand (1997) which provides respondents with full range of bid amounts prior to giving any valuation responds. This makes it more appropriate for the respondent make an overall valuation considering other valuation questions.

It should be noted that there was a significant loss of data due to non-responses to some valuation questions, particularly for the STC sample population where 50% to 60% of the participants did not answer some of the WTP question (Table 5.2). This may have been partly a result of the fact that, due to research budget constraints, I did not oversee the collection of data in the STC area, and those who conducted the surveys may not have fully understood data collection requirements. To understand the reasons why some respondents did not answer certain WTP questions, their attitudes towards some of the unanswered questions were evaluated based on their debriefing comments. For the respondent who did not respond to the questions, the reason that was most commonly reported was related to their perception of the importance or relevance of the environmental change (as indicated in the debriefing comments). Some of the comments submitted included, 'STC watershed does not have issues of water odour', 'STC had no recreation activities' etc. In addition, for those respondents who did not answer, the reason may have been due to their insufficient income to support sustainable environmental attributes, (as suggested in collected comments). For instance, “I do not have enough funds to support this, I guess it’s the responsibility of city”. Since the problem of nonresponse existed with method of collections, I dealt with the high level of non-responses by comparing respondents to the population (Miller and Smith, 1983) to determine whether or not non-responses caused biasedness of values estimated. This required comparing information about the background characteristics of the population. If there are differences, the results only can be generalized to the respondents (Lindner, et al., 2001). However, social value seemed the same as sample value estimation as illustrated later in Table 5.10.

Table 5.2 Non-responses from STC sample data

	Water Clarity 1	Water Clarity 2	Water Odour 1	Water Odour 2	Water Quantity 1	Water Quantit y2	Recreat -ion 1	Recreat-ion 2
Non respo nse (%)	50.0	53.0	56.0	56.0	54.0	54.0	57.0	55.0

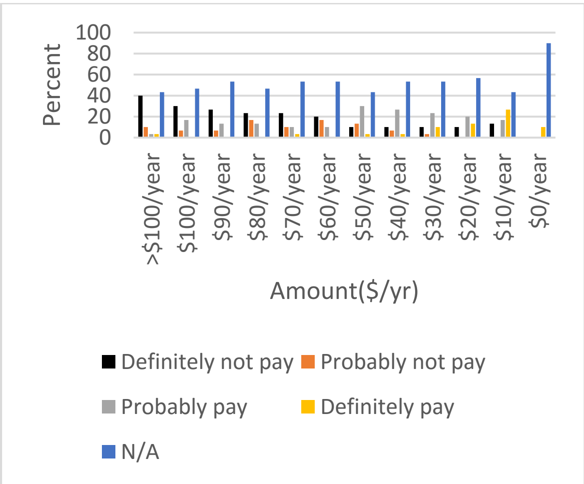
5.3.1 STC Valuation Response

The respondents provided value estimates for a total of eight scenarios, concerning four attributes, for each study area. The actual response frequency distributions for the STC sample population valuation questions for each change in environmental quality are provided in Figures 5.1 to 5.2. The response distribution for the WC scenario is presented in Figure 5.1a and 5.1b reflecting perspectives of WC1 and WC2. At the lowest positive bid level of \$10 year^{-1} for WC1 only 26.7% of respondents indicated that they would “definitely pay” while 16.7% indicated they would probably pay (43.4% indicating a WTP). For the WC2 scenario (Figure 5.1b), 10.2% indicated probably pay and 28.5% indicated they would definitely pay at \$10 year^{-1} bid (38.7% indicating a WTP). Approximately 10% of respondents switched from probably pay to definitely pay at \$40 year^{-1} and \$50 year^{-1} for the WC1 and WC2 scenarios respectively. In view of this, respondents seem to be willing to pay more for an improvement in water clarity from medium level to a relatively higher level than for an improvement from poor quality to medium quality.

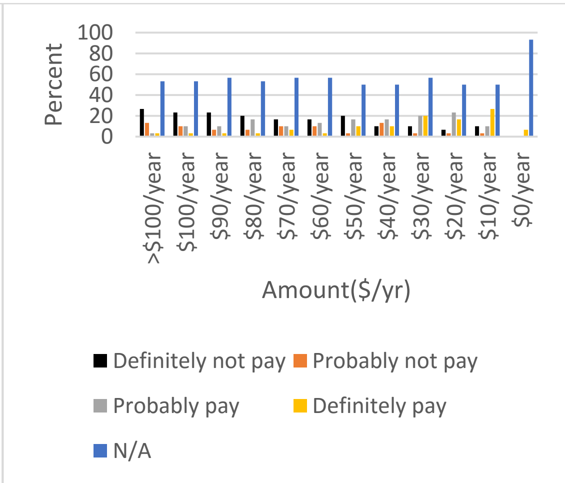
The response distribution for the WO scenario is presented in Figure 5.1c and 5.1d, denoted WO1 and WO2. For the WO1 scenario (Figure 5.1c), approximately 33.4% of the 18 respondents indicated “definitely pay” or “probably pay” at \$20 year^{-1}. For the WO2 scenario, approximately 30% out of those who responded to this question stated they will definitely pay or probably pay at \$20 year^{-1}. Approximately 10% of the respondent changed from probably pay to definitely pay at \$30 year^{-1} for both WO1 and WO2 scenarios reflecting an increase in WTP. The change from probably pay to definitely pay reveals the threshold of WTP. This reveals where they are uncertain about a payment (probably pay) to where they state their actual WTP (definitely pay). Again WO1 and WO2 scenarios represented the most poorly responded to question because it appeared that respondents had no concerns with water odour based on their debriefing comments. However, the proportion identifying a WTP decreased as bid amounts increased which suggests that those who did respond were interpreting the questions correctly based on economic theory.

STC

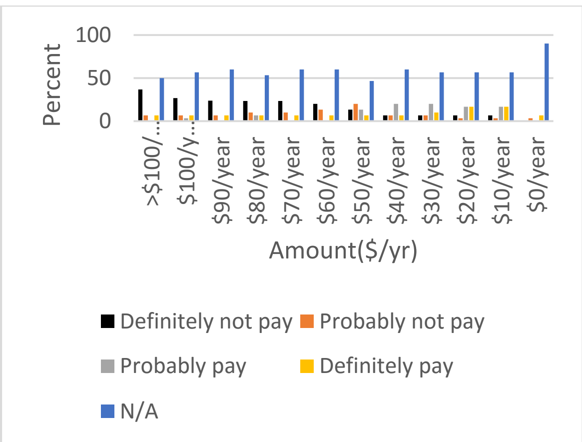
a



b



c



d

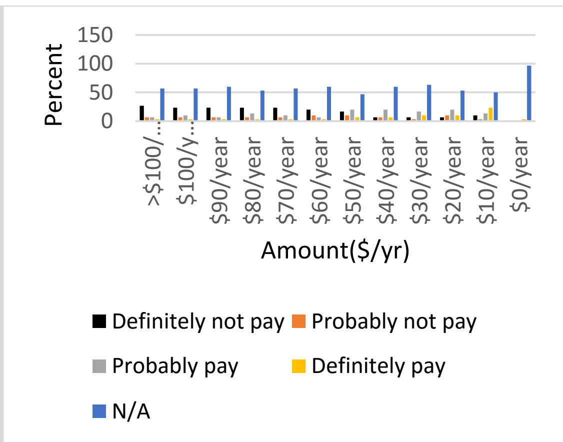


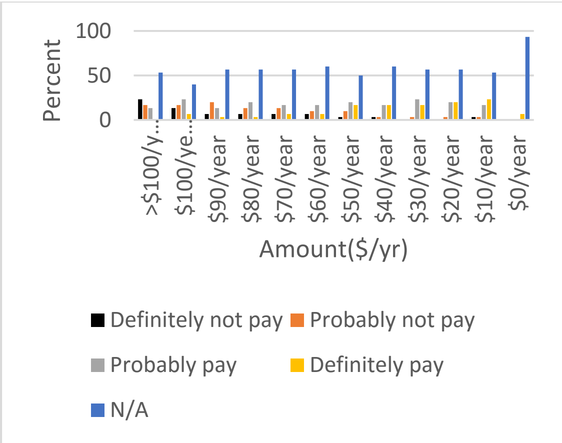
Figure 5.1 Response distribution for WC1 (a), WC2 (b), WO1(c), WO2 (d) for the STC respondents. N/A is non-response

For WQ scenarios (Figure 5.2 e and f), respondents were asked their WTP for reduced flood frequency. The response distribution for the WQ scenario presented in Figure e and f, reported as WQ1 and ‘WQ2. For the STC sample population, the water quantity scenarios responses appeared to reflect a high perceived importance ascribed to flood issues by the respondents. The province of Manitoba has experienced significant flood damages in recent years. In early April 2011, Manitoba declared a high flood risk for six rivers, including two that pass through Winnipeg (Government of Manitoba, 2011). The 2011 flood featured the highest water levels and flows in modern history across parts of Manitoba. Again in 2013, torrential rain and flash floods prompted more than 100 communities in Manitoba to declare a state of emergency and about 698 people in Manitoba had to leave their homes because of overland flooding (Government of Manitoba, 2013).

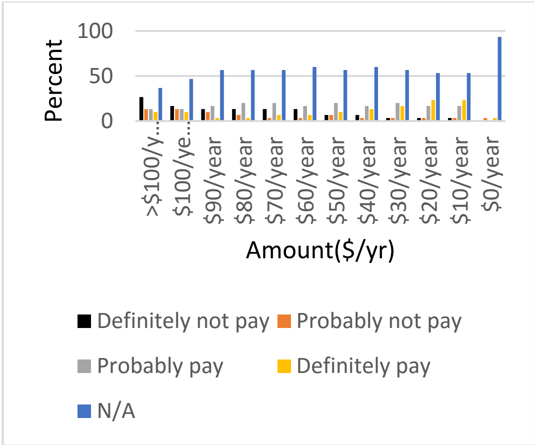
For the WQ1 scenario, approximately 23.3% selected “definitely pay” at \$10 year^{-1} out of the respondents who completed this question. Approximately 10.6% of respondents switched from \$60 year^{-1}, where they indicated a probably pay; to \$50 year^{-1} where they identified definitely pay. This point indicates the level of increase in WTP for WQ1. For the WQ2 scenario (Figure 5.2e), there was a rise and fall of definitely pay responses. A rise in definitely pay from \$100 year^{-1} and fall from \$90 year^{-1} through to \$50 year^{-1} and then another rise from \$50 year^{-1}. Approximately 6.7% indicated that they would definitely pay at \$60 year^{-1}. From observing the response distribution alone, there is no clear threshold for switching from no-responses to yes-responses in scenarios, when compared to the WQ1 scenario.

For the RF scenarios respondents were asked for their WTP for increased recreation activities and fish populations. The response distribution for RF scenario is presented in Figure 5.2 g and h and reflects responses of RF1 and RF2. For the RF1 scenario (Figure 5.2g), 23.3% of those who responded to this question indicated that they will definitely pay at \$10 year^{-1}. The RF2 scenario gave fairly different results as 56% of respondents will definitely pay at \$10 year^{-1}. However, for RF2 scenario, approximately 18.6% picked “definitely pay” at \$20 year^{-1} which is fairly similar in results with the RF1 scenario with 19.2% at the same bid. Meanwhile approximately 60% of respondents indicated in their comments and debriefing questions that there are no recreation activities in and around the STC and so they were unwilling to pay monetary compensation for this environmental improvement.

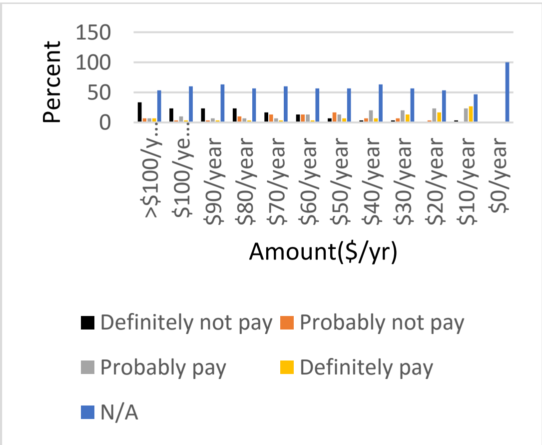
STC



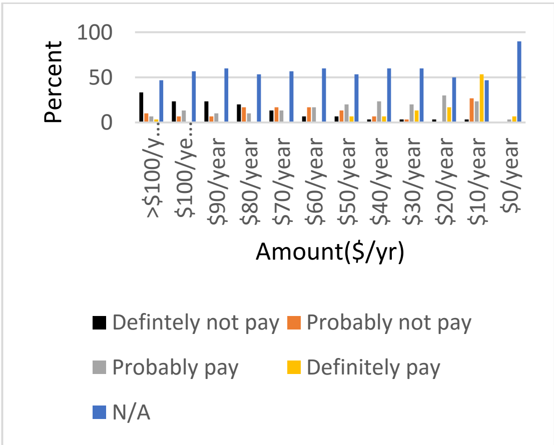
e



f



g



h

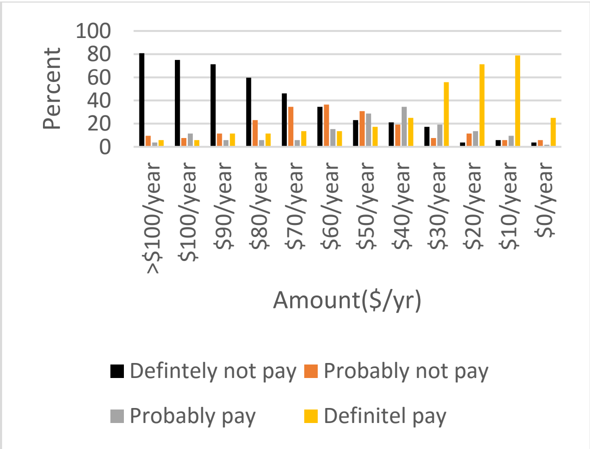
Figure 5.2 Response distribution for WQ1 (e), WQ2 (f), RF1 (g), RF2 (h) for the STC respondents. N/A is non-response

5.3.2 Ag Days Manitoba Valuation Responses

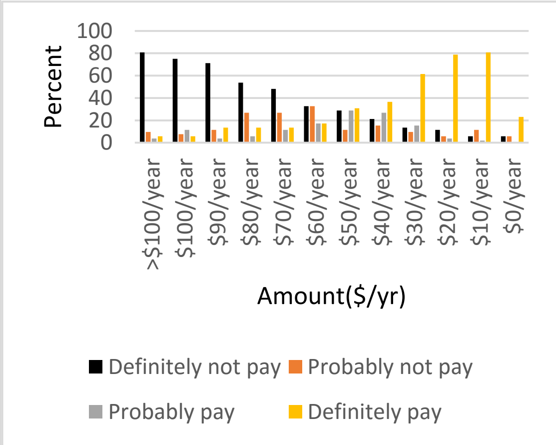
The Ag Days sample population response distribution for the WC1 and WC2 questions is presented in Figures 5.3i and 5.3j. In responding to these valuation questions, some respondents were not willing to pay for some environmental improvements as identified in debriefing comments and questions that followed the valuation questions in the survey. Some of the respondents stated they were not willing to pay financial compensation for improvements in water clarity and water odour since they do not have issues with these water quality parameters in their area. Approximately 55.8% of the respondents indicated that for WC1 they would definitely pay at \$30 year^{-1}. Furthermore, 19.2% of the respondents indicated they will probably pay at the same bid. As expected, a greater proportion of respondents indicate their WTP as the bid level decreased for WC1. For WC2, 61.5% of the respondents indicated they will definitely pay and 15.4% indicated that they would probably pay at \$30 year^{-1} bid (76.9% indicating a WTP). This shows that the Ag Days attendees from western Manitoba have similar preferences with respect to WC1 and WC2. Overall, the Ag Days sample population shows a higher WTP for water clarity improvements than the STC population. One explanation for this different result is the fact that the Ag Days population were not constrained to the STC watershed in their valuation decision as they may be considering a watershed where this environmental improvement is more important.

For the WO1 scenario, approximately 58% of all respondents selected “definitely pay” at \$20 year^{-1}. For the WO2 scenario (Figure 5.3l), there is a similar distribution as in WO1 but a slightly larger proportion of respondents indicated WTP at \$20 year^{-1} (69.2% of the respondents). However, there is a clear threshold for switching from probably pay responses to definitely pay responses at \$40 year^{-1}. In other words, the actual WTP determination is evident from the \$40 year^{-1} to the lowest bid of \$10 year^{-1}.

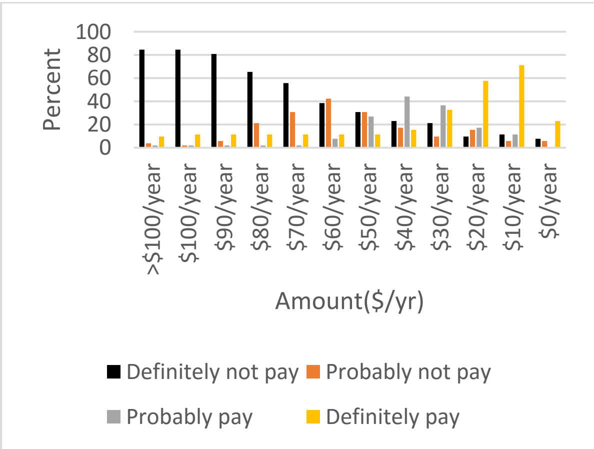
Ag Days



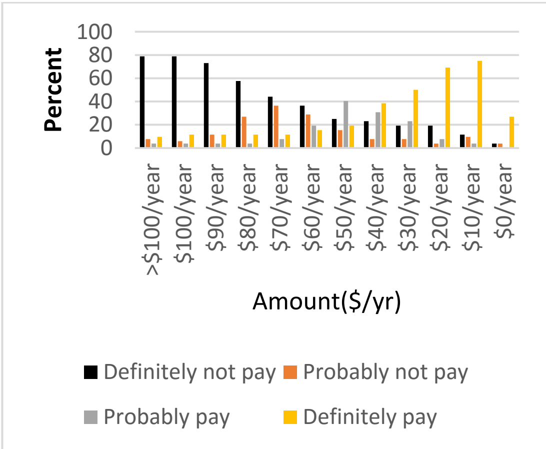
i



j



k



l

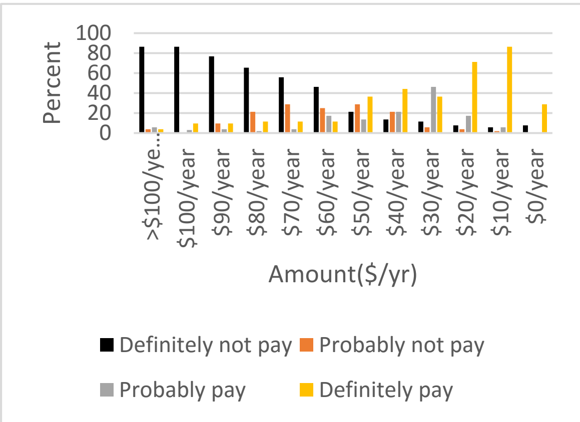
Figure 5.3 Response distribution for WC1 (i), WC2 (j), WO1 (k), WO2 (l) for the Ag Days respondents. N/A is non-response

For the WQ scenarios (Figure 5.4 m and n), respondents were asked their WTP for reduced flood frequency. The response distribution for the WQ scenario is presented in Figure 5.4 panels' m and n reported as WQ1 and WQ2. For the Ag Days sample population, the water quantity scenarios responses also appeared to reflect a perceived importance ascribed to flood issues by the respondents. As discussed earlier, the province of Manitoba has experienced significant flood damages in recent years. For the WQ1 scenario, approximately 86% selected "definitely pay" at \$10 year^{-1} out of the respondents who completed this question. For the WQ2 scenario (Figure n), there was a rise of definitely pay responses from bid \$50 year^{-1} to \$10 year^{-1}. Approximately 85% indicated that they would definitely pay at \$20 year^{-1} and \$10 year^{-1}.

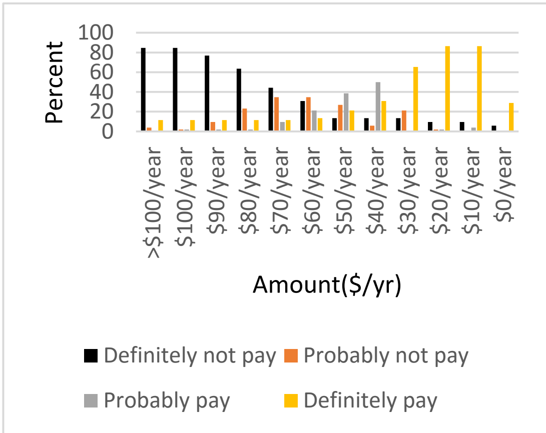
From observing the response distribution alone, there is clear threshold for switching from definitely not pay to definitely pay for WQ1 and WQ2 scenarios.

For the RF scenarios respondents were asked for their WTP for increased recreation activities and fish populations. The response distribution for the RF scenario is presented in Figure 5.4, panels o and p and reflect responses to changes in the scenario from ‘limited recreation’ to ‘fishing possible’ (RF1) and ‘fishing possible’ to ‘all recreation activities allowed’ (RF2). For the RF1 scenario (Figure o), 84% of those who responded to this question, indicated that they will definitely pay at $10 year^{-1}. The RF2 scenario gave fairly similar results as 82% of respondents will definitely pay at $10 year^{-1}.

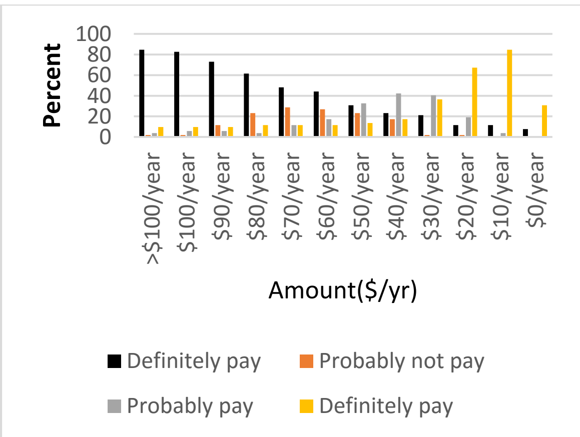
Ag Days Manitoba



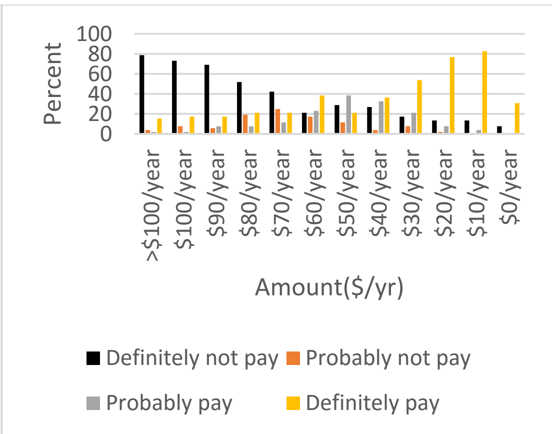
m



n



o



p

Figure 5.4. Response distribution for WQ1 (m), WQ2 (n), RF1 (o), RF2 (p) for the Ag Days respondents. N/A is non-response

5.4 WTP for Environmental Improvements

The estimation of offsite benefits of agricultural BMPs is a crucial step in the evaluation of BMPs in the provision of a range of public goods; including water quality, flood mitigation and recreation services. As argued earlier, this information will help in the evaluation and development of appropriate BMP policy. Boyle (2003) stated that if values of public environmental goods such as flood reduction, unpolluted water, or biodiversity cannot be derived from observation of individual behavior in the context of markets (revealed preferences), they are commonly determined by responses to questions in surveys (stated preferences). Contingent valuation was used in this study to elicit the WTP values that people place on goods and services (environmental services) that could be provided by the adoption of BMPs by farmers within the watershed.

The mean WTP (MWTP) values were calculated by finding the average of the bid values that respondents indicated that they would definitely pay. The estimated MWTP value represents the amount that a household would be willing to pay through increased annual property taxes, in Canadian dollars for the specified increase in the quality of the environmental parameter. In general, for the 4 environmental attributes evaluated, respondents reported a higher MWTP for an increase in environmental quality from an intermediate level to a higher level than for an increase an environmental quality from a poor state to an intermediate state.

5.4.1 WTP Results from STC

The MWTP calculated based on responses from the STC sample population are presented in Table 5.3. As expected the probably pay values were greater than the definitely pay values, suggesting the respondents interpreted the valuation questions correctly. Of the BMP related environmental attributes considered by the STC population in this research, water odour was the least valued with a MWTP of \$19.66 $year^{-1}$ for an improvement from 'odour throughout the ice free season' to 'odour only in July and August'(WO1), and \$23.67 $year^{-1}$ for improvement from 'odour only in July and August' to 'no odour' (WO2). The most valued attribute was water quantity (flood reduction) which had an estimated value of \$45 $year^{-1}$ for 'reduced flood frequency from every 1.5 years to every 5 years' (WQ1), and approximately \$50 $year^{-1}$ for 'reduced frequency from every 5 years to every 10 years' (WQ2).

Table 5.3 Estimation of WTP for each environmental attribute for STC sample population

Environmental Quality Changes (Attributes)	Mean WTP/household (CAD$/yr.)	
	Definitely pay	Probably pay
Water Clarity 1 (from murky to moderately clear)	25.00	43.00
Water Clarity 2 (from moderately clear to clear)	32.00	44.33
Water odour 1 (odour throughout the ice season to odour only in the warmest season)	19.66	31.66
Water odour 2 (odour in warmest season to no odour)	23.67	37.33
Water Quantity 1 (reduced flood frequency from every 1.5 years to 5 years)	45.00	56.67
Water Quantity 2 (reduced flood frequency from every 5 years to 10 years)	49.67	57.33
Recreation and Fish Habitat (Limited recreation to fishing possible)	23.00	32.33
Recreation and Fish Habitat 2 (Fishing possible to all recreation activities allowed)	25.33	34.00

Source: Field survey, 2016

5.4.2 WTP Results from Ag Days Manitoba Sample Population

Consistent with the findings from the STC sample population, improvements in water odour (WO) was the least valued attribute for respondents from the Ag Days sample population (Table 5.4). Similarly, improvements in water quantity (flood reduction) was the highest valued attribute with \$36.25 year^{-1} for 'reduced flood frequency from every 1.5 years to every 5 years' (WQ1), and \$41.37 year^{-1} for 'reduced flooding from every 5 years to every 10 years' (WQ2). The MWTP for increasing water clarity from 'murky to moderately clear' (WC1) was estimated at \$30.88 year^{-1} while the MWTP for an increase in recreation and fish population from 'limited recreation to fishing possible' (RF1) was \$32.21 year^{-1}.

Table 5.4 Estimation of WTP for improvements in each environmental attribute for the Ag Days Manitoba sample population

Environmental Quality Changes (Attributes)	Mean WTP/household (CAD$/yr.)	
	Definitely pay	Probably pay
Water Clarity1 (from murky to moderately clear)	30.88	43.27
Water Clarity2 (from moderately clear to clear)	35.38	44.71
Water odour 1 (odour throughout the ice season to odour only in the warmest season)	24.42	37.11
Water odour 2 (odour in warmest season to no odour)	27.88	42.50
Water Quantity 1 (reduced flood frequency from every 1.5 years to 5 years)	36.25	48.29
Water Quantity 2 (reduced flood frequency from every 5years to 10 years)	41.37	48.84
Recreation and Fish Habitat (Limited recreation to fishing possible)	32.21	40.19
Recreation and Fish Habitat 2 (Fishing possible to all recreation activities allowed)	36.76	47.88

Source: Field survey, 2016

5.4.3 Comparison of WTP values for the two Sample Populations

Results from Ag Days sample population, when compared to the STC results, indicated relatively higher MWTP for all changes in the quality of the environmental attributes. Generally, respondents from the Ag Days sample population indicated that they would be willing to pay more for each environmental attribute at the various levels. Further, the variability of MWTP is shown by the range and standard deviation for each environmental attribute (Table 5.5). There is a lower variability in the MWTP responses for all four environmental attributes for the Ag Days sample population. Overall variability between attributes range \$20-\$50 for STC and \$24-\$41 for Ag days depicting a higher range of values of attributes for STC sample population.

To enable an evaluation of the impact of geographic location, and other demographic attributes, of the two sample populations on mean WTP it is useful to provide a side by side comparison. Figure 5.7 reports the mean WTP values from the STC and Ag Days sample populations for improvements to all four environmental attributes from 1) a low level to medium and 2) medium level to a higher level. Generally, mean WTP for the Ag Days sample was relatively higher than the STC sample population for all environmental quality changes under study except water quantity (WQ; flood reduction).

Table 5.5 Variability in MWTP for each attribute for STC and Ag Days sample populations

	STC MWTP (CAD$/yr.)	Range	Standard Deviation	Ag Days MTWP (CAD$/yr.)	Range	Standard Deviation
WC1	25.00	7.00	4.95	30.88	4.50	3.18
WC2	32.00			35.38		
WO1	19.66	4.01	2.84	24.42	3.46	2.44
WO2	23.67			27.88		
WQ1	45.00	4.67	3.30	36.25	5.12	3.62
WQ2	49.67			41.37		
RF1	23.00	2.33	1.65	32.21	4.55	3.21
RF2	25.33			36.76		

However, the relative magnitude of the mean WTP was consistent across the attributes and levels. For example, the average WTP for WC1 by respondents in STC was about \$25 year^{-1} and by respondents in Ag Days sample was around \$30.88 year^{-1} which suggests that Ag Days sample population respondents have a higher WTP than those sampled in STC. In addition, water quantity improvements from flood reduction BMPs at both levels were viewed as the most highly valued environmental change. The STC and Ag Days respondents valued flood reduction respectively at \$46 year^{-1} and \$36.25 year^{-1} for WQ1 and \$50 year^{-1} and \$41.37 year^{-1} for WQ2. These results seem to indicate that flood issues are perceived as one of the major environmental problems in the study areas and in the STC watershed in particular where WQ1 and WQ2 were the only studied attributes that received higher relative values. The results from both regions in western Manitoba look quite consistent which indicates relatively good data and, for that matter, reflects respondents' perception about environmental attributes. The Ag Days WC1 WTP is 23.5% higher than the STC WTP while the Ag Days WO1 WTP is 24.2% higher than the STC. Moreover, Ag Days RF1 WTP is 40.1% higher than the STC. However, the STC WQ1 and WQ2 are 19.4% and 20.1% higher than Ag Days WTP for WQ1 ad WQ2, respectively. The difference in values also reflects the fact that the STC population was constrained to consider values for that specific watershed whereas the Ag Days population had no such constraint. This finding also has direct implication for policy development. According to the restriction which was faced by respondents in STC, it is possible to conclude that a BMP such as small dam or water retention structure would be more suitable in STC area because a larger proportion of the population was willing to bear the cost of this BMP. Engeman et al., (2003) interpreted total WTP as the summation of each of the indicators values in a monetary valuation of wildlife protection. Moreover, the WTP value of an environmental changed attributed to BMP will increase as more indicators are added (Engeman et al., 2003). Overall, this study is expected to help inform policy makers by quantifying the value of some of the society's preferences towards environmental improvements provision in Manitoba.

5.5 Personal Characteristics and WTP Values

The purpose of this analysis is to examine the effect that personal characteristics have on the decision to pay for improved environmental attributes. For this analysis, an econometric regression model was used, where the dependent variable is WTP, while the independent variables include age, education, income, home area and gender. These personal characteristics parameters were selected on the basis of literature concerning the willingness to support environmental improvements, while other variables were included because they have been hypothesized to influence respondents' decision to support an environmental improvement (Wu et al., 2002).

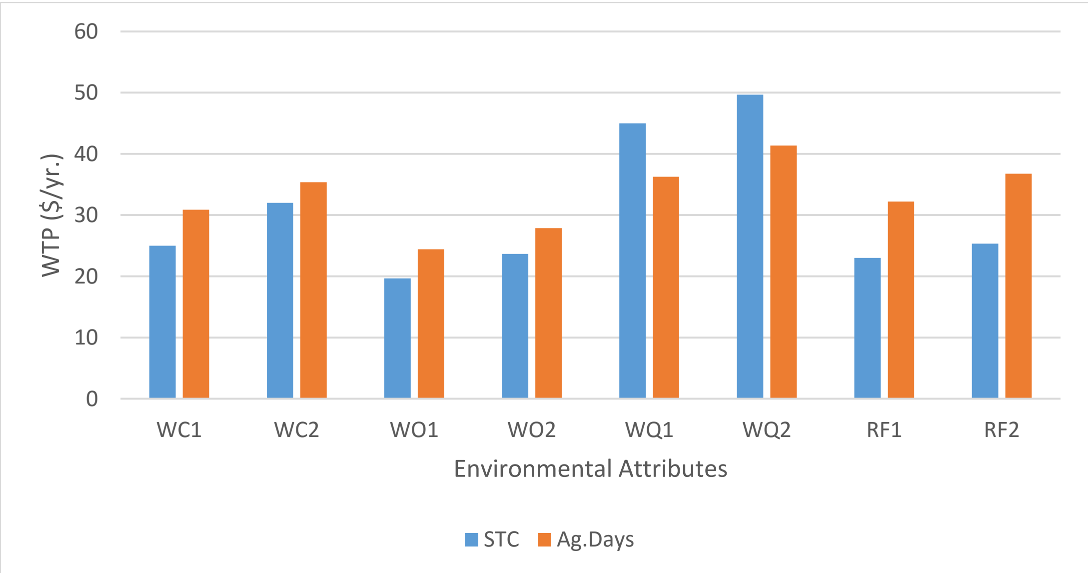


Figure 5.7 Mean WTP for all eight environmental quality changes at the two study areas

5.5.1 STC Regression Results

The discussion of regression results will focus on selected scenarios from each region and attributes based on those regression models that had a better fit with the data, more significant variables and general model significance. However, all of the regression results from both sample populations with difference attributes are included in Appendix C. Moreover, there exists practical limitations to my data and analysis since there is relatively small sample size and low response rate which restricts the inference which could be drawn from the analysis.

The estimated outcome of the probit model used to analyze respondents' decision on WTP value for WQ is presented in Table 5.6. The interpretation of the results is provided in this section. The analytical results indicated that the estimated OLS model was a good fit with an F-stat value statistically significant at the 10% level. This indicates that respondent personal characteristics are relevant in explaining the WTP decision in the study area. Another measure of good fit is the R^2 value of 0.617, which indicates that 61.7% of the variations in the respondent's decision to pay for water quantity are explained by the independent variables in the model. The R^2 value is high for a cross sectional study. Following a diagnostic test, high R^2 in the OLS model could be attributed to multicollinearity, thus, two independent variables in the multiple regression model are highly correlated, meaning that one can be linearly predicted from the others with a substantial degree of accuracy (Greene, 2003). In other words, multicollinearity makes the coefficient estimates unstable and difficult to interpret. However, Greene (2003) argues to leave the model as is, despite multicollinearity since the presence of multicollinearity doesn't affect the overall fit of the model or produce bad predictions. The numbers in the parentheses, below the coefficient values in Table 5.6, are the standard error of the regression coefficient which measures how closely the model estimates the coefficient's unknown value. The standard error values in both models indicated there is fairly small deviation of calculated coefficient values from the unknown coefficient value and this is an indicator of fairly good model output. The inverse Mills ratio (IMR) is statistically significant at 5% implying that employing the two stage procedure is appropriate and justifies the use of the Heckman model. This indicates that there is no sample selection problem in the model and thus estimating determinants of the amounts respondents are willing to pay using an OLS model would be accurate and yields unbiased estimates.

In the OLS model developed for the attribute scenario improvement in water quantity (WQ1), household income did not have a statistically significant influence on the WTP for flood reduction (from every 1.5 years to every 5 years). For example, wealthier respondents were not willing to pay more for the decrease in flood frequency than those with less income. This may be influenced by the possibility that wealthier respondents might have put risk reducing practices in place to mitigate flood damage including, for example, location of house and buildings, dikes, insurance. While this result does not appear to be consistent with economic theory, a considerable number of studies on contingent valuation of environmental goods and services have reported insignificant income effect on WTP (Misra et al., 1991; Fu et al., 1999). Education was also found to be insignificant in respondents' valuation of decreased flooding frequency. One explanation is that a more highly educated person may be more aware of environmental problems attributable to non-agricultural sources and thereby considering agriculture itself as a less significant influence on flood frequency (Nimoh et al., 2011). Moreover, age, gender and home area turned out to be unimportant in explaining the WTP for decreased flood frequency. However, this result is somewhat contrary to the findings of earlier studies (Kwadzo et al., 2013; Long et al., 2013) which sought to estimate household WTP for decreased flooding frequency.

For WQ2, decreasing flood frequency from every 5 years to every 10 years, the relationship between education (respondent with some college education) and the WTP was observed to be positive and statistically significant at the 5% significance level. This suggests that persons with some college educational background are willing to pay \$77.9 $year^{-1}$ more than those who have less education to decrease flood frequency at these levels. Household income at the level of \$75,000-\$99,999 $year^{-1}$ had a statistically significant positive effect on the WTP for decreased flood frequency. That is, respondents with income level between \$75,000 and \$99,999 were willing to pay \$78.9 $year^{-1}$ more than those with income of less than \$25,000 $year^{-1}$. This could reflect that individuals are more interested in the total flood control than an intermediate flood control since even less frequent flood events may cause damage to lives and properties. This means an individual with the same income range will pay more for WQ2 than WQ1. However, the correlation between education and income is not significant (Appendix C). The estimated outcome of the Heckman selection model used to analyze respondents decision concerning WTP for water clarity for WC1 (murky to moderately clear) and WC2 (moderately clear to clear) is shown in Table 5.7. The OLS regression coefficients indicate that respondent personal characteristics were relevant in explaining the magnitude of WTP in the study area. The R^2 value of 0.578 indicates that 57.8% of the variations in the magnitude of the individual WTP for water clarity are explained by the independent variables in the model. This is quite reasonable considering that the data for the study was obtained from cross sectional survey of individuals in the study area.

Table 5.6 Effects of personal characteristics on WTP for reduced flooding in STC

	Heckman Selection Model		Heckman Selection Model	
	WQ1(From every 1.5yrs to 5yrs)		WQ2(From every 5yrs to 10yrs)	
Variable	Probit model	OLS model	Probit model	OLS model
Constant	4.307	-27.183	4.948*	-47.855
	(2.715)	(72.663)	(2.868)	(79.165)
Educ(High school)	-0.673	102.527	-1.108	92.716
	(1.353)	(89.502)	(1.520)	(97.512)
Educ(Some college)	-0.006	69.205	-0.885	77.908**
	(1.498)	(38.808)	(1.513)	(18.16)
Educ (2 year degree)	0.532	-0.567	1.560	25.463
	(1.688)	(48.340)	(1.892)	(52.666)
Educ (4year degree)	-1.490*	61.644	-0.603	83.566
	(1.465)	(62.784)	(1.377)	(68.403
Gender	-0.878	30.483	-1.256*	28.636
	(0.801)	(37.308)	(0.705)	(40.647)
Y(25000-49999)	-1.050	87.453	-2.722	87.008
	(1.566)	(47.967)	(1.669)	(52.260)
Y(50000-74999)	0.609	13.451	-1.174	20.800
	(1.311)	(33.760)	(1.190)	(36.971)
Y(75000-99999)	-0.149	52.214	-2.049	78.931*
	(1.852)	(36.688)	(1.917)	(39.971)
Y(100000 above)	1.879*	-6.937	0.111	-2.923
	(2.076)	(82.864)	(1.884)	(90.279)
Age(45-59)	-1.567	0.149	-0.890	13.408
	(1.589)	(61.571)	(1.379)	(67.081)
Age(60 above)	-2.677	-37.893	-2.071	29.648
	(1.832)	(30.575)	(1.549)	(112.559)
HomeArea (Rural)	-1.018	23.800	-1.402	14.240
	(1.094)	(44.903)	(1.146)	(48.992)
HomeArea(Urban)	-2.007	48.143	-2.616	31.078
	(1.371)	(83.031)	(1.654)	(90.462)
Mills Ratio		2.114**		-112.533
		(60.207)		(228.271)
Observations	30	24	30	24
R^2		0.617		0.603
Adjusted R^2		0.022		0.013
Log Likelihood	-5.521		-5.521	
F-Statistics		1.038*(df=14, 9)		0.978(df=14,9)

Note: Robust standard errors *p<0.1, **p<0.05, ***p<0.01 ; the values in the parenthesis are standard errors
Y is income, Educ is Education
Age is Age, HomeArea is Home Area

In the OLS model income, age and gender had no significant effect on the amount/magnitude of WTP for WC1 in STC. However, education had positive effects on support for water clarity while home area had a negative influence. In the OLS model, the coefficient for education (educ2) was positive and statistically significant at the 10% level. The positive effect on the WTP implies that respondents with high school education are willing to pay \$29 year^{-1} more for improved water clarity compared to those with no formal education. Living in urban areas was found to be significant at the 10% significance level. Considering the OLS model for WC1 and WC2, the estimated coefficients are -\$40 and -\$79 respectively. That is, a respondent who reside in urban areas were willing to pay \$40 less for water clarity improvements from murky to moderately clear, and \$79 less for improvements from moderately clear to clear, than those living on a farm. This could be that urban residents always have the water cleaned and purified by the city and so perceived water clarity was not considered their responsibility and/or the likelihood that rural residents live beside or close to the surface water bodies may also increase their preferences. All regressions for recreation and water odour for the STC sample population are included in Appendix C.

5.5.2 Ag Days Manitoba Regression Results

The estimated outcome of the probit and OLS models used to analyze respondent decisions on WTP for water clarity from murky to moderately clear (WC1) is reported in Table 5.8. The interpretation of the results is also provided in this section. The analytical statistics showed that the estimated model was a good fit with an F-stat value statistically significant at the 5% level. The log likelihood is not statistically significant which mean the regression coefficients in the model are zero. This indicates that in the model respondent personal characteristics were relevant in explaining the WTP decision in the study area. The R^2 value of 0.424 indicates that 42.4% of the variations in the magnitude of WTP for water clarity are explained by the dependent variables in the model. This is quite reasonable considering that the data for the study was obtained from cross sectional survey of individuals in the study area. The IMR is statistically significant at 5% thus implying that employing the two stage procedure is appropriate and justifies the use of the Heckman model.

Table 5.7: Effects of personal characteristics on WTP for water clarity in STC

Variable	Heckman Selection Model WC1(From murky to moderately clear)		Heckman Selection Model WC2(From moderately clear to clear)	
	Probit model	OLS model	Probit model	OLS model
Constant	2.413	49.297	4.376	36.679
	(2.178)	(74.075)	(2.734)	(93.859)
Educ(High school)	-0.497	29.28*	-0.747	23.093
	(1.274)	(67.65)	(1.311)	(59.848)
Educ(Some college)	-0.639	22.44	-0.542	54.321
	(1.498)	(60.753)	(1.335)	(40.896)
Educ(2 year degree)	-0.351	45.643	0.066	61.130
	(1.421)	(45.582)	(1.485)	(44.821)
Educ(4 year degree)	-0.730	61.644	-1.219	41.781
	(1.295)	(62.784)	(1.353)	(60.587
Gender	-0.432	-15.871	-1.039	-25.375
	(0.615)	(39.441)	(0.716)	(42.912)
Y(25000-49999)	-0.603	-0.113	-1.420	20.778
	(1.269)	(53.463)	(1.566)	(54.154)
Y(50000-74999)	0.167	13.330	-0.396	-19.506
	(0.907)	(50.774)	(1.102)	(26.248)
Y(75000-99999)	1.053	-22.573	-0.579	78.931*
	(1.552)	(107.291)	(1.852)	(39.971)
Y(100000above)	0.394	-7.368	1.879	-2.923
	(1.389)	(82.864)	(2.076)	(90.279)
Age(45-59)	-1.331	-12.671	-1.567	13.408
	(1.158)	(110.540)	(1.589)	(67.081)
Age(60 above)	-1.386	-31.879	-2.354*	-34.259
	(1.832)	(125.106)	(1.832)	(111.505)
HomeArea(Rural)	-1.018	-10.111	-0.747	-21.916
	(1.094)	(28.220)	(1.152)	(28.405)
HomeArea(Urban)	0.370	-40.005*	-0.277	-79.386*
	(1.080)	(51.692)	(1.371)	(90.462)
Mills Ratio		17.945		30.533
		(195.303)		(114.534)
Observations	30	21	30	22
R^2		0.578		0.731
Adjusted R^2		-0.407		0.193
Log Likelihood	-15.103		-5.521	
F-Statistics		0.587(df=14, 6)		1.358 (df=14,9)

Note: Robust standard errors *p<0.1, **p<0.05, ***p<0.01
Y is income,
Educ is Education
Age is Age
HomeArea is Home Area

As reported in Table 5.8, there are two significant coefficients for WC2 and none for WC1 in the probit model. This implies that the probability of a respondent decision to pay is 2.316 and 1.317 for age (Age3) and Home area (Home area 3). This means that an individual with Age3 has an increased probability of payment of 2.316 while an individual with HomeArea3 increases the probability of payment by 1.317. For the OLS model, there were three significant coefficients each for WC1 and WC2. The OLS regression coefficients reflecting the influence of demographic characteristics on the amount a respondent is willing to pay for an environmental improvement.

The coefficient for education (educ4) was positive and statistically significant at the 10% level and also in line with previous studies such as of Ali (2013) and Danso-Abbeam et al. (2014). The positive effect on the magnitude of the WTP implies that respondents with two year degree level of education are willing to pay $32 more for improved water clarity compared to those with no formal education. However, findings from Kwadzo et al. (2013) observed a negative correlation between farmers' educational level and WTP for improved environmental attributes explaining that the more educated a respondent is the more exposed they are to environmental issues and opportunities to adopt sophisticated management practices to address them. Living in rural and urban areas was found to be significant at the 10% and 5% significance level, respectively and positively correlated with respondents WTP for water clarity. This is consistent with other studies including Nimoh et al. (2011) and Long et al. (2013). Income, age and gender had no significant effect on the WTP for water clarity at both levels (WC1 and WC2) in the OLS model. The interaction between age and income, and income and education etc. were positive but not significant, which is inconsistent with a comparable study like Do and Bennett (2009). The result from my study suggests that, for example, an older person who is wealthier will be willing to pay more for an increase in water clarity than a younger person who is middle class income earner. All other econometrics results which have not shown or explained in this results section have been included in Appendix C.

Table 5.8 Effects of personal characteristics on WTP for water clarity in Ag Days Manitoba sample

	Heckman Selection Model WC1(murky to moderately clear)		Heckman Selection Model WC2(moderately clear to clear)	
Variable	Probit model	OLS model	Probit model	OLS model
Constant	-1.327 (1.525)	0.657 (39.46)	-1.646 (1.567)	-5.733 (37.73)
Educ(2 year degree)	0.263 (1.279)	31.609* (16.75)	0.608 (1.245)	30.786* (16.78)
Educ(4 year degree)	-0.374 (1.057)	2.867 (18.49)	-0.139 (1.063)	1.509 (18.16)
Gender	0.032 (0.685)		-0.057 (0.684)	
Y(25000-49999)	1.263 (1.261)		1.058 (1.298)	
Y(50000-74999)	0.747 (1.226)	12.202 (17.06)	0.611 (1.240)	19.388 (15.22)
Y(75000-99999)	2.015 (1.332)	0.812 (18.96)	1.405 (1.297)	1.227 (18.96)
Y(100000above)	2.022 (1.332)	21.344 (21.31)	1.976 (1.346)	21.794 (20.01)
Age(45-60)	0.830 (0.910)	-20.915 (21.261)	0.834 (0.899)	-11.880 (19.19)
Age(60 above)	1.898 (1.228)	-22.413 (30.575)	2.317* (1.301)	-11.740 (27.96)
HomeArea(Rural)	0.622 (1.149)	40.596** (17.756)	1.125 (1.143)	42.055** (20.24)
HomeArea(Urban)	0.768 (0.708)	29.287* (15.201)	1.316* (0.745)	35.776* (17.54)
Mills Ratio		2.114** (60.207)		0.144 (50.22)
Observations	52	43	52	36
R^2		0.424		0.310
Adjusted R^2		0.220		0.129
Log Likelihood	10.476		-6.128	
F-Statistics		2.075**(df=11,31)		0.982(df=11,31)

Note: Robust standard errors *p<0.1, **p<0.05, ***p<0.01
Y is income,
Educ is Education
Age is Age
HomeArea is Home Area

The effects of socioeconomics factors on the WTP decision for flood reduction in the Ag Days Manitoba population showed that the estimated probit model was a good fit with an F-stat value statistically significant at 10% level (Table 5.9). This suggests that respondent personal characteristics were relevant in explaining the WTP decision for decreased flooding frequency in the study area. The R^2 value of the OLS model indicates that 28.9% of the variations in the respondent's decision to pay for water quantity are explained by the independent variables in the model.

As reported in Table 5.9, there is one significant coefficients for WQ1 and five for WQ2 in the probit model. This implies that the probability of a respondent with an income range of \$75,000-\$99,999 decision to pay is 2.316 for WQ1, whereas decision to pay for WQ2 for a respondent living in urban area is 1.316. From the OLS regression results, the coefficient of income (\$50,000-\$74,999) was positive and statistically significant at the 10% level. That is, respondents with income level between \$50,000 and \$74,999 were willing to pay \$44.9 $year^{-1}$ more than those with income of less than \$25,000 $year^{-1}$. Subsequently, respondent with four year degree level of education were willing to pay \$30 $year^{-1}$ more for WQ2 than individuals with no formal education or schooling. Age of the respondent was found to be significant at the 5% level and negatively correlated with the respondent's WTP for WQ2. That is, respondents with age level 45-59 years and 60 years above were willing to pay \$43.29 $year^{-1}$ and \$60.32 $year^{-1}$ more, respectively, than the younger respondents.

Table 5.9 Effects of personal characteristics on WTP for reduced flooding in Ag Days Manitoba sample

	Heckman Selection Model		Heckman Selection Model	
	WQ1(From every 1.5yrs to 5yrs)		WQ2(From every 5yrs to 10yrs)	
Variable	Probit model	OLS model	Probit model	OLS model
Constant	-1.327	0.657	-3.029*	39.337
	(1.525)	(39.46)	(1.701)	(36.470)
Educ(2year degree)	-0.325	15.956	0.627	28.047
	(1.329)	(20.999)	(1.146)	(16.78)
Educ(4year degree)	-0.699	24.003	-0.502	30.355**
	(1.077)	(18.834)	(1.071)	(18.16)
Gender	0.577		0.991	
	(0.670)		(0.766)	
Y(25000-49999)	1.263		1.928	
	(1.268)		(1.288)	
Y(50000-74999)	2.547	44.964*	2.950*	28.309
	(1.226)	(17.06)	(1.240)	(22.751)
Y(75000-99999)	2.314*	40.900	2.964**	24.669
	(1.369)	(30.522)	(1.494)	(22.936)
Y(100000 above)	1.983	45.875	3.347**	38.719
	(1.329)	(27.252)	(1.526)	(24.859)
Age(45-59)	0.940	-34.516	0.781	-43.296**
	(0.959)	(26.069)	(0.926)	(19.631)
Age(60 above)	1.904	-34.324	2.317*	-60.328**
	(1.322)	(36.890)	(1.301)	(27.96)
HomeArea (Rural)	0.252	11.134*	1.125	6.916
	(1.131)	(19.014)	(1.143)	(15.729)
HomeArea(Urban)	0.466	-5.177	1.316*	-9.113
	(0.737)	(15.958)	(0.745)	(13.835)
Mills Ratio		62.930		7.333
		(74.332)		(43.864)
Observations	52	45	52	46
R^2		0.289		0.342
Adjusted R^2		0.052		0.129
Log Likelihood	-9.404		-9.404	
F-Statistics		1.219*(df=11,33)		1.606(df=11, 34)

Note: Robust standard errors *p<0.1, **p<0.05, ***p<0.01
Y is income,
Educ is Education
Age is Age
HomeArea is Home Area

Improving the environmental condition from a medium state to a relatively higher state was valued more than improvements from a low level to a medium level in both sample areas. This could be attributed to the fact that, individual perceived the medium to relatively higher scenarios could be attained through adoption of advanced and sophisticated BMPs which could be expensive in implementing hence their high values. Moreover, optimum welfare gains or total eradication of welfare losses associated with the medium to higher scenario could also result in individual higher values. However, WTP for flood reduction frequency at both levels was significantly greater for the STC sample than the Ag Days sample. For the other three tested environmental improvements WTP values in Ag Days were relatively higher than in STC which may have been influenced by higher incomes and education levels in the Ag Days sample population, which have been found to be positively related to WTP (Do and Bennett, 2007). Also STC responses were restricted to considering the value of environmental changes within the STC watershed while Ag Days population were not restricted and thus would have considered the values of environmental changes of watersheds in general.

The Heckman model was run using the survey data collected from the two designated study areas. Results from the two study areas did not differ significantly. The econometric results for the STC sample population had similar coefficient estimates (representing the amount willing to pay) for water clarity, water odour and recreation as found for the Ag Days sample population. According to the econometric model results, respondents' decisions were mainly influenced by their home area, income and education. WTP values from the two sample population are fairly consistent which suggests good quality data. Although diagnostic problems such as multicollinearity were encountered because of the interaction of dependent variables from the two sample populations, they should not have affected the outcome of the analyses or precision of estimates (Greene, 2003). Generally, the probit model did not yield many significant coefficients in all eight models. Residency of the respondent was the prevailing significant variable under the probit model. The OLS model yielded more significant coefficients than the probit model. Mainly income, education, home area and age variables had one or two significant coefficients.

5.6 Linking Values of Environmental Changes to Specific BMPs

The relationship between specific BMPs and the WTP monetary values from this study can be evaluated using a qualitative framework that highlights the potential level of relative contribution to each of the environmental attributes (Table 5.10). This qualitative framework has been developed due to the absence of sufficient quantitative data to link a particular BMP to a specific environmental improvement. The qualitative framework presented in Table 5.10 uses plus and N/A symbols to signify the quality of links between the specific BMP listed for the STC watershed and the environmental improvement. Within the table plus signs indicate a positive effect linkage of environmental changes to a specific BMP with the greater number of plus signs reflecting a stronger link, or stronger influence on the environmental change, and a larger improvement in environmental quality linked to the BMP. Conversely, N/A indicates a lack of contribution of an environmental change by a specific BMP management.

The external benefits described in this section are provided to place the valuation work in context but should not be taken as a complete assessment of the BMPs' impacts. They represent an over-simplification of the complexities of the prairie ecosystem. For the purpose of this thesis, the impacts on water clarity are assumed to result only from sediment and not through nutrient enrichment, and the mixed results regarding the impacts of perennial forages and conservation tillage on water quantity are reported as no significant impact.

Research has shown that through the retention of water from runoff, sediment and nutrients are reduced since particulates in runoff water that are normally exported from the fields can settle out in reservoirs. Examples of the economic benefits gained by water retention BMPs, such as implementing small dams and reservoirs, include improvements in water quality, reductions in downstream impact, and savings in infrastructure spending (Haugland, 2007). In Oklahoma, Sharpley et al. (1996) reported that a runoff retention pond reduced sediment by more than 80%, with nutrient export dropping by more than 50%. Tiessen et al. (2011), in a study of the STC watershed, reported that for the Steppler and Madill dams, peak flows and export of sediment were significantly reduced in both snowmelt and rainfall related runoff. The small dams could collectively reduce peak flows by 9 to 19% for snowmelt runoff and 13 to 25% for rainfall events. In this study the authors stated that reduction of sediment, as total suspended solids (TSS) was reduced by more than 60% which can increase water clarity. Based on the literature, it seems that small dams have the potential to contribute significantly to reduced water flows (flood reduction) which is reflected in Table 5.10 with three plus signs, reduce sedimentation of waterbodies which may increase recreational activities which is reflected by one plus sign and trap significant sediments and nutrients which improves water clarity and is represented by three plus signs.

Under conservation tillage, the crop residue buffers the rain or snow's energy, so water has less erosive force when it reaches the soil (Tiessen et al., 2010). In terms of water clarity impacts, Tiessen et al. (2010) showed that sediment and total N export were reduced on average by 65% per year respectively by adoption of conservation tillage when comparing runoff from a conservation and conventional tillage fields. In other words, conservation tillage could significantly improve water clarity as denoted by three plus signs in Table 5.10. Recreation activities are improved under the conservation tillage BMP, since sediment loadings are reduced and this is represented by one plus sign. There is no consistently reported link between conservation tillage and water flow (Tiessen et al., 2010).

Nutrients loadings could be managed and reduced using certain BMP management. These could lead to the linkages to environmental benefits as shown in Table 5.10.

Table 5.10 Specific BMP and their external benefits

BMPs	Water Clarity	Water Odour	Water Quantity	Recreation Fish
Small dams and reservoirs	+++	N/A	+++	+
Conservation tillage	+++	N/A	N/A	+
Winter bale-grazing	---	---	N/A	-
The conversion of annual cropland to perennial forage	++	N/A	N/A	+
Holding pond downstream of a winter cattle containment area	+++	+++	+	+

It has been reported that uncontrolled runoff from livestock sites can transport nutrients and pathogens to surface water and runoff can pick up nutrients from manure and through erosion of soil (Chambers and Dale, 1997). The holding pond BMP captures runoff from livestock yards or wintering sites which can further improve downstream water clarity, odour, and to some extent, peak flows during heavy snow melts. A report by AAFC (2009) indicated that, holding ponds are highly effective at capturing runoff with high nutrient concentrations and E. coli counts from the cattle feedlot, thus helping prevent these contaminants from draining into the stream. In a multi-year study, Li et al. (2011) reported that retention of nutrients in the holding pond could account for as much as a 63% reduction in total N and a 57% reduction in total P leaving a cattle feedlot site in the STC. Based on this literature, it seems that holding pond BMP could contribute to improved water clarity and odour significantly, denoted in Table 5.10 by three plus signs. Kemper and Popp (2008) showed that lake water quality, particularly, water odour, clarity and aesthetics, has significant impact on recreation use and land values. This is to say that improved water clarity and odour could possibly increase recreation activities.

The perennial forage conversion BMP has the potential to prevent sedimentation since the land is not left without vegetative cover, but is always covered with a forage. This helps improve water clarity as denoted by one plus sign. Forage crops could also enhance wildlife habitat and increase recreation activities significantly under perennial forage crop conversion denoted by three plus signs (Table 5.10). There is no consistently reported link between conversion from annual crop to forage and water odour or flow rate.

In-field overwintering of cattle through bale or swath grazing reduces costs for the producer but unless the location is carefully selected it can have a negative impact on water quality (Smith et al., 2011). Runoff from bale grazed sites can contain elevated concentrations of nutrients and pathogens that can negatively impact water clarity, odour and recreational value.

From a policy perspective, providing incentives to producers to implement BMPs which seek to reduce flooding will have more appeal to society and, it’s likely to be a better option, based on findings from the qualitative framework. According to the qualitative framework presented in Table 5.10, it is possible to conclude that the externality associated with environmental changes that positively impact flood reduction is greater than the other environmental attributes. Based on survey data the social value of flood reduction is expected to be higher than the others attributes. The need to prevent flood damage is an issue of importance in Manitoba and the role of BMPs in providing flood reduction benefits is increasingly recognized by society and policy makers. Again, from the Table 5.10, the most favourable BMP in the south western Manitoba is the small dams and reservoirs. Conversely, least favoured environmental changes are therefore winter bale grazing BMP would have a lower priority.

5.7 Weighted Mean WTP from two Sample Population

Using the data from the STC and Ag Days surveys and equation 4.6, the weighted mean WTP value for all eight (8) environmental improvements was computed. For example, weighted mean for WC_1 is calculated using w_1= 30 which is weight of STC sample in the entire population/ sample size of STC, w_2= 52, weight of Ag Days sample in the entire population/ sample size of Ag Days, X_1 = \$25.00 year^{-1}, which is the mean of WC_1 at STC and X_2 = \$30.88

year^{-1} which is the mean value of WC1 at Ag Days. Using equation 4.6, the weighted mean (social value) for WC_1 was estimated to be \$28.73 year^{-1} household^{-1} (Table 5.11). The social value for improvements in water clarity was estimated at \$28.73 year^{-1} to \$34.14 year^{-1} household^{-1} for WC1 and WC2 respectively, which are relatively low when compared to relevant estimates reported by Duffield et al. (1992) who estimated water clarity improvements necessary for recreational trips at \$57 year^{-1} (1991 dollars) in Montana. The least valued attribute in my study was improvements in water odour with a social value of \$22.68 year^{-1} to \$26.34 year^{-1} for the weighted mean WTP values from two samples. Reduced Flooding frequency had the highest social value of \$39.45 year^{-1} to \$44.41 year^{-1} for the weighted mean WTP values from two samples. These values are consistent with Berrens et al. (1996) who measured the WTP for control of peak flows in four rivers in New Mexico and scaled up their results to estimate WTP for all rivers at \$49 year^{-1} (1996 dollars) which is higher than estimates in the present study. Lastly, the average WTP for recreation and fish habitat was estimated at \$28.84 year^{-1} to \$32.58 year^{-1} for the weighted mean WTP values from two samples. I could not find any directly comparable studies due to different scales, however Roberts and Leitch (1997), who employed the CVM to determine that the combined habitat, recreation, and aesthetic values for the wetland complex reported a social value of \$21 (1997 dollars) acre^{-1} year^{-1}.

Table 5.11 Social value for Environmental Improvements

Environmental Attributes	Weighted WTP values ($/year)
Water Clarity1 (from murky to moderately clear)	**28.73**
Water Clarity2 (from moderately clear to clear)	**34.14**
Water odour 1 (odour throughout the ice season to odour only in the warmest season)	**22.68**
Water odour 2 (odour in warmest season to no odour)	**26.34**
Water Quantity 1 (reduced flood frequency from every 1.5 years to 5years)	**39.45**
Water Quantity 2 (reduced flood frequency from every 5years to 10years)	**44.41**
Recreation and Fish Habitat (Limited recreation to fishing possible)	**28.84**
Recreation and Fish Habitat 2 (Fishing possible to all recreation activities allowed)	**32.58**

Source: Survey Results, 2016

Results from respondents from two study areas seem to be within the range of values for environmental improvements observed in other studies across North America. Nevertheless, this study's results provide important implications for BMP policy development. The fact that flood reduction improvements had the greatest WTP in both sample population is a strong indication that respondents ascribe greater value to improvements in flood reduction. As suggested by this social value from the weighted average computation, a policy that targets incentives provision to farmers to adopt BMP which will provide flood reduction will have more appeal to society and, it's likely to be a better option from a social welfare perspective.

5.8 Policy Implications

The insights provided in this thesis can inform policy makers involved in BMP policy development, improvements and delivery as well as other types of conservation policy. The literature suggests that these policy strategies should be designed on the basis of the benefit-cost effective principle and target resources which yield the greatest environmental amenities which could be achieved using limited public funds (Wu et al., 1997, 2001; Belcher, 2008). Therefore, it is unlikely that any one policy would be efficient for all options available. This research contributes to understanding societal perspectives and preferences concerning the allocation of financial support for the improvement of the environment. This is an area that has been under researched in the literature. The specific contributions of my research to these policy questions will now be discussed.

Considering the WTP results estimated in this research, the relatively higher importance ascribed to flood reduction benefits of BMPs by the survey respondents suggests that society would be more responsive and supportive of policy measures targeted at BMPs that contribute most directly to flood reduction benefits. The fact that, floods impose a more direct personal loss while water quality, clarity and recreation provide a gain, often shared among society, is one reason why flood reduction may be more valued than other attributes of environment. Also economic theory suggests that welfare losses (often reflected using willingness to accept non market valuation) are usually valued higher than gains (WTP) (Granato, 2014). That is to say individual will pay more to avoid losses (such as those imposed by flooding) than to pay for an improvement or benefit. Moreover, the qualitative inquiry of linking values to specific BMPs provided insights into the types of BMPs adoption to encourage and supported by governments. The fact that flood reduction improvements had the greatest WTP in both econometric model and qualitative frameworks is a strong indication that participants recognise greater value in improvements in flood reduction, therefore providing incentives to producers to adopt BMP which yields flood reduction will have more appeal to society. Based on the qualitative analysis, BMPs such as small dams and reservoirs and holding ponds should be encouraged and implemented.

Government supported payment for BMP adoption as policy instruments can be informed by these research results by providing insight into the size of incentive respondents from the sample populations would support, or not support, for environmental improvements. From a policy perspective, other conservation compatible practices which usually do not require large conversion costs nor require direct financial assistance from governments may also be encouraged. A focus on practices which will improve water clarity, water odour, recreation opportunities and reduce flood frequency should be encouraged.

As suggested by this research, a high level of income and education means that when possible, policy initiatives should be directed to those groups based on their demographic characteristics. For example, for a region with a high level of income, a BMP incentive policy framework would have stronger support since people in that region have high demands for improve environmental quality supported by their in-depth knowledge in environmental sustainability. The qualitative study of linking values to specific BMPs also hints that segments of the public might value environment improvement as a tool to shape what they consider to be appropriate types of agricultural practices.

5.9 Summary

This chapter described the estimation of social values, as represented by WTP values, for specific environmental changes related to water quality and quantity associated with BMP adoption. Individual characteristics were also modeled to determine the impact of these characteristics on both the individual decision to pay for environmental improvements as well as the magnitude of the payment willing to be provided. The data from the two sample population data produced comparable results. According to the results, society is WTP more for flood reduction and would be willing to pay the least for improved water odour. Age and gender characteristics also have limited or no significant influence in the decision to pay for environmental improvements. In the next section, discussion of summary results, limitations of study and areas of future studies are provided.

CHAPTER 6
SUMMARY AND CONCLUSION

6.1 Introduction

This chapter provides a summary of findings and results of the research, a brief explanation of the conceptual framework, and the development of a specific case study to quantify external benefits of non-market values of some environmental attributes. A WTP method was applied to achieve this goal. A discussion of methods and an empirical model were presented to examine the policy in encouraging adoption of BMP which yields environmental benefits associated with water quality and water quantity. This is followed by a discussion of survey results and policy implication from the present study. Finally, the limitations of the study and areas of future research are discussed.

6.2 Summary

Economic valuation plays a supportive role in BMP policy and the development of adoption incentives and also informing policy development through the process of estimating the value to society. The literature explored in Chapter 2 highlighted some of the benefits provided by BMPs; the problems related to externalities, and some of the valuation tools and methods available to help policy development. In this study, values of water clarity, water odour, water quantity and recreation changes attributed to BMP adoption were investigated. The empirical analysis conducted in this study investigated how society values water clarity, water odour, water quantity and recreation and factors that may influence how much is society would be willing to pay to support such improvements. A face to face survey was employed to a sample of residents of the STC watershed and participants of the Ag Days farm show in Brandon, Manitoba. The survey was composed of four sections, an introduction, the WTP elicitation, the level of confidence, and demographic information. The survey was completed by 82 participants from both sample populations.

The results indicated that respondents will be willing to pay for improvement in water clarity, water odour, water quantity and recreation; however, water quantity (flood reduction) improvements at both levels were viewed as the most highly valued environmental change, whereas decreased water odour at both levels were the least valued environmental improvement. The STC sample populations valued flood reduction at \$45 year^{-1} household^{-1}, for reduction in flood frequency from every 1.5 years to 5 years, and \$50 year^{-1} for reduction in flood frequency from every 5 years to 10 years. For Ag Days population, reduced flooding was valued at \$36 $year^{-1}$ $household^{-1}$ for reduction in flood frequency from every 1.5 years to 5 years and \$41 $year^{-1}$ $household^{-1}$ for reduction in flood frequency from every 5 years to 10 years In addition, the social value for decreased water odour was estimated at \$19.66 $year^{-1}$ for odour throughout the ice season to odour only in the warmest season and \$23.67 $year^{-1}$ for improvements from odour in warmest season to no odour. Moreover, this study applied the Heckman two regression models to determine respondents' characteristics effect on decision to pay for environmental improvements and influence on the magnitude of their WTP. Overall, this study is expected to help inform policy makers to encourage the adoption of those BMPs which yield benefits which are of higher social values in Manitoba.

Qualitative analysis revealed how values of water clarity, water odour, water quantity (flood reduction) and recreation could be linked to specific BMPs. As reflected by the analysis developed, small dams and reservoirs could contribute significantly to flood mitigation. The holding pond BMP could also improve water clarity and water odour, and for that matter increased recreation activities. To be able to inform development of appropriate policy, weighted means for two sample population was calculated. Flood reduction had the highest social value (weighted mean) of \$44.41 $year^{-1}$ $household^{-1}$ for reduced flood frequency from every 5 years to 10 years and water odour least valued at \$22.68 $year^{-1}$ $household^{-1}$ for odour throughout the ice season to odour only in the warmest season.

6.3 Limitation of Study

There are some specific limitations that need to be considered when using and applying the results from the present study. There was a level of sample bias evident in the data collection and analysis. The samples were compared to Census of Manitoba population data and the study sample populations did not show clear representation of Manitoba population. The small sample size in this present study limited the scope of fitting complex econometric models for the estimation of societal WTP for environmental improvements. Hence, the focus was on obtaining the estimates and distributions of WTP from relatively simpler econometric models that best fit the data and then comparing the estimates to see if the results are consistent across various econometric models. Moreover, high levels of non-respondents from the STC sample population could increase the likelihood of bias (Lindner et al., 2001, p. 52), which will render analysis not appropriate for generalization.

The limitation of examining environmental improvement based on survey data from sample populations representing relatively distinct agricultural landscapes limits the applicability of the results. Studies could be conducted over different landscapes to capture the impact of various characteristics of other respondents based on their immediate environment. This will help effectively target the allocation of resources for the adoption of BMPs which yield different environmental benefits.

6.4 Areas of Future Research

There is a large body of research that focus on demand for environmental improvements. To be able to establish a comparison between demand and supply sides of valuation, research efforts need to shift from valuation from demand side to valuation from the supply side (i.e. cost of supplying environmental services from landowners' perspective based on adoption of BMPs, as by studies developed in Australia (Stoneham et al., 2003). For example, research which looks at the cost of supplying services from the landowners' perspective based the adoption of BMP.

Secondly, future research could focus on different models of policy delivery including cost share BMP incentive payment, environmental tax to encourage adoption of BMPs other than the current study which focuses primarily on government funding for the adoption of BMP revealed by social valuation. Though all these programs are economic incentive policies, each will have difference participation and valuation impacts.

Lastly, understanding the biophysical relationship between a specific BMP and the environmental outcome would assist policy makers to make decision that yield greater environment benefits with targeted resources. This information would also be important to producers who are expecting greater financial incentives to implement BMP which seeks to protect the environment, since agriculture production activities on surrounding vegetation might also contribute to environmental degradation. Therefore, future research is needed to examine the influence of conservation programs on environmental attributes improvements and the potential related costs involved.

REFERENCES

Agricultural and Agri-Food Canada (2002). South Tobacco Creek/Steppler Watershed". Retrieved November 07, 2016. http://www4.agr.gc.ca/AAFC-AAC

Agriculture and Agri-Food Canada (2004). Watershed Evaluation of Beneficial Management Practices (WEBs) 2003/04 Annual Report, Valerie Stuart, Ed. ISSN 1913-4355. 3.

Agriculture and Agri-Food Canada (2005). Agricultural Policy Framework. Reviewed January 25, 2016. http://www.agr.gc.ca/AAFC/display-afficher.do?=1181580600540

Agricultural and Agri-Food Canada (2008). South Tobacco Creek/Steppler Watershed. Retrieved November 15, 2015,fromhttp://www4.agr.gc.ca/AAFC-AAC

Agricultural and Agri-Food Canada (2009). South Tobacco Creek/Steppler Watershed. Retrieved April 9, 2016,fromhttp://www4.agr.gc.ca/AAFC-AACAgriculture and Agri-Food Canada. (2010). Watershed Evaluation of Beneficial Management Practices (WEBs) Technical Summary #2 – Economics Component Four-Year Review (2004/5 - 2007/8). Agriculture and Agri-Food Canada. Ottawa. Ontario.

Agriculture and Agri-Food Canada (2011). Watershed Evaluation of Beneficial Management Practices (WEBs) 2006/07 Annual Report, Valerie Stuart, Ed. ISSN 1913-4355. (3).

Agriculture and Agri-Food Canada (2016). Growing Forward 2. http://www.agr.gc.ca/eng/about-us/key-departmental-initiatives/growing-forward-2. Retrieved August 07, 2016

Alberini, A., Boyle, K., and Welsh, M. (2003). Analysis of contingent valuation data with multiple bids and response options allowing respondents to express uncertainty. Journal of Environmental Economics and Management 45(1): 40-62.

Alberta Agriculture and Rural Development (AARD) (2004). Beneficial Management Practices: Environmental Manual for Crop Producers in Alberta. Alberta Agriculture and Rural Development, Edmonton, Alberta, Canada.

Ali, A. (2013). Farmers' Willingness to Pay for Index Based Crop Insurance in Pakistan: A Case Study on Food and Cash Crops of Rain-fed Areas. Agricultural Economics Research Review 26(2): 241-248

Anderson, S., Harrison, G.W., Lau, M.I. and Rutström, E.E. (2006). Elicitation using multiple price list formats. Experimental Economics 9: 383-405.

Austin, R.W. (1973). Problems in Measuring Turbidity as a Water Quality Parameter. U.S. EPA Seminar on Methodology for Monitoring the Marine Environment. October 16-18, 1973, Seattle, Washington

Batie, S. (1984). Agricultural Policy and Soil Conservation: Implications for the 1985 Farm Bill. Washington DC: American Enterprise Institute.

Barzel, Y. (1997). Economic Analysis of Property Rights, 2nd edn. (Cambridge: Cambridge University Press)

Belcher, K.W. (2008). The targeting of Canadian agri-environmental policy: An analysis of suitability. Seminar draft, University of Saskatchewan, Saskatoon, Canada.

Bertrand, R. (1999). State of resources report: Based on farm practices surveys conducted in 1998 and 1999. Abbotsford, BC: BC Ministry of Agriculture.

Berrens, R.P., Ganderton, P., and Silva, C.L. (1996). Valuing the Protection of Minimum Instream flows in New Mexico. Journal of Agricultural and Resource Economics 21(2):294–309.

Birol, E., Karousakis, K., and Koundouri, P. (2006). Using a choice experiment to account for preference heterogeneity in wetland attributes: the case of Cheimaditida wetland in Greece. Ecological Economics, 60 (1), 145 – 156.

Bishop, J.T. (1999). Valuing Forests: A Review of Methods and Applications in Developing Countries. Environmental Economics Programme International Institute for Environment and Development (IIED).

Bishop, R.C. and Heberlein, T.A. (1979). Measuring values of extra market goods: are indirect measures biased? American Journal of Agricultural Economics: 926-930.

Blundell, R. (2005). How revealing is revealed preference? European Economic Journal, 3:211–235.

Bockstael, N.E., Freeman, A.M. Kopp, R.J., Portney, P.R. and Kerry Smith, V. (2000). On measuring economic values for nature. Environmental Science and Technology 34: 1384-1389

Bosch, D.D., Potter, T.L., Truman, C.C., Bednarz, C.W., and Strickland, T.C. (1994). Surface runoff and lateral subsurface flow as a response to conservation tillage and soil water conditions. Transaction of the American Society of Agricultural Engineers, 48(6), 2137-2144

Boyle, K.J. and Bishop, R.C. (1988). Welfare measurements using contingent valuation: a comparison of techniques. American Journal of Agricultural Economics 70(1): 20-28.

Boyle, K.J. (2003). Contingent Valuation in Practice. In Patricia A. Champ, Kevin J. Boyle, and Thomas C. Brown. A Primer on Nonmarket Valuation. Dordrecht, Netherlands: Kluwer Academic Publishers 111-171.

Brown, M.A. (2001). A step-by-step guide to non-linear regression analysis of experimental data using a Microsoft Excel spreadsheet. 65, 3, 191–200

Brox, J.A., Kumar, R.C., and Stollery, K.R. (1996). Willingness to pay for water quality and supply enhancements in the Grand River watershed. Canadian Water Resources Journal. 21(3):275-288.

Brox, J.A., Kumar, R.C., and Stollery, K.R. (2003). Estimating willingness to pay for improved water quality in the presence of item nonresponse bias. The American Journal of Agricultural Economics 85(2):414-428.

Byrne, J.P. (2004). Property and environment: thoughts on an evolving relationship. Part of the 2004 National Student Federalist Society Symposium on Law and Public Policy. Georgetown University Law Center.

Carlsson, F., Frykblom, P., and Liljenstolpe, C. (2003). Valuing wetland attributes: an application of choice experiments. Ecological Economics, 47, 95–103

Chambers, C.M., Paul, E., Chambers, J., and Whitehead, C. (1998). Contingent Valuation of Quasi-Public Goods: Validity, Reliability, and Application to Valuing a Historic Site. Public Finance Review 26(2): 137-154.

Chambers, P.A. and Dale, A.R. (1997). Contribution of industrial, municipal, agricultural and groundwater sources to nutrient export, Athabasca, Wapiti and Smoky rivers, 1980 to 1993. Northern River Basins Study, Edmonton AB

Champ, P.A., Bishop, R.C., Brown, T.C., and McCollum, D.W. (1997). Mechanism to Value nonuse Benefits from Public Goods. Journal of Economics and Management, 33(2), 151-162

Chase, L.C., Lee, D.R., Schulze, W.D., and Anderson, D.J. (1998). Ecotourism Demand and differential Pricing of National Park Access in Costa Rica, Land Economics, 74(4), 466-482

Chee, Y.E. (2004). An Ecological perspective on the valuation of ecosystem services. Biological Conservation. 20(4), 549-565

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., and Hannon, B. (1997). The Value of the World's Ecosystem Services and Natural Capital. Nature, 387, 253-260.

Courtney, E., and Courtney, M. (2013). Data Analysis, Statistics, and Probability, Cornell University Library, 2013

Cummings R.G., and Taylor, L.O. (1999).Unbiased Value Estimates for Environmental Goods: A Cheap Talk Design for the Contingent Valuation Method. The American Economic Review, 89(3), 649-665

Dabney, S.M. (2003). Erosion control, Vegetative. In Encyclopedia of Soil Science, 209-213. R. Lal. New York, N.Y.: Marcel Dekker

Daily, G.C., Söderqvist, T., Aniyar, S., Arrow, K., Dasgupta, P., Ehrlich, P.R., Folke, C., Jansson, A., Kautsky, N., Levin, S., Lubchenco, J., Mäler, K., Simpson, D., Starrett, D., Tilman, D., and Walker, B. (2000). The Value of Nature and the Nature of Value. Science 289, 395-396

Danso-Abbeam, G., Addai, K.N., and Ehiakpor, D. (2014). Willingness to Pay for Farm Insurance by Smallholder Cocoa Farmers in Ghana. Journal of Social Science for Policy Implications 2(1): 163-183. ISSN: 2334-2900 (Print), 2334-2919 (Online).

Debo, T.N., and Reese, A.J. (2003). Municipal Storm water Management (2nd Ed.). Boca Raton, FL: CRC Press. ISBN 1-56670-584-3.

Deerwood Soil and Water Management Association. (2000). Watershed-based community development: creating lasting and positive change in rural Manitoba. 15

De Groot, R.S., van der Perk, J., Chiesura, A., and Marguliew, S. (2000). Ecological functions and socio-economic values of critical natural capital as a measure for ecological integrity and environmental health. Ecological Economics, 191-214

Dillman, D.A., and Christenson, J.A. (1972). ‘‘The Public Value for Pollution Control.’’ In Value for Pollution Control, Social Behavior, Natural Resources and the Environment.

Do, T., and Bennett, J. (2007). Willingness to pay for wetland improvement in Vietnam’s Mekong River Delta. Australian Agricultural and Resource Economics Society. 51st Annual Conference

Duffield, J.W., Neher, C.J., and Brown, T.C. (1992). Recreation benefits of instream flow: application to Montana’s Big Hole and Bitterroot rivers. Water Resources Research 28(9):2169–2181

Dupont, D.P. (2000). Gender and willingness to pay for recreational benefits from water quality improvements. Proceedings of the Tenth Biennial Conference of the International Institute of Fisheries Economics and Trade, July 10-14, 2000.

Ducks Unlimited Canada (DUC) (2006). Wetland restoration as Beneficial Management Practice http://www.ducks.ca/aoutduc/news/archives/2006/06011.html. Retrieved June 07, 2016

Engeman, R.M., Schwiff, S.A., Smith, H.T., and Constantin, B. (2003). "Monetary valuation methods for economic analysis of the benefit-costs of protecting rare wildlife species from predators." USDA National Wildlife Research Center – Staff Publications. 88

Environmental Protection Agency (EPA) (1998). Threats to wetlands. http://www.epa.gov/owow/wetlands/pdf/threats.pdf. Retrieved July 04, 2016

Florida Department of Agriculture and Consumer Services (FDACS) (2007). http:// www.freshfromflorida.com/Divisions-Offices/Agricultural-Water-Policy. Retrieved August 17, 2016

Feather, M.P. and Cooper, J. (1995). Voluntary Incentives for Reducing Agricultural Nonpoint Source Water Pollution. USDA; Economic Research Service; Agriculture Information Bulleting Number 717.

Freeman, A. (2003). 'Valuing Environmental Goods: An Assessment of the Contingent Valuation Method. Rowman and Littlefield Savage, Maryland.

Fu, T.T., Liu, J.J., and Hammitt, J. (1999). ''Consumer Willingness to Pay for Low-Pesticide Fresh Produce in Taiwan.'' Journal of Agricultural Economics 50 (May): 220-33.

Goolsby, D.A., Thurman, E.M., Pomes, M.L., Meyer, M. and Battaglin, W.A. (1993). "Occurrence, Deposition, and Long Range Transport of Herbicides in Precipitation in the Midwestern and Northeastern United States," in Goolsby

Government of Manitoba (2011). Water management framework. Government of Manitoba.

Government of Manitoba (2013). Spring Flood Outlook for Manitoba. Government of Manitoba .https://www.gov.mb.ca/flooding

Granato, G.E. (2014). Statistics for stochastic modeling of volume reduction, hydrograph extension, and water-quality treatment by structural storm water runoff best management practices (BMPs) (Report). U.S. Geological Survey. Scientific Investigations Report 2014–5037.

Greene, W.H. (2003). Econometric Analysis. Pearson Education, Inc., New Jersey 663-755

Hamelett J.M., and Epp, D.J. (1994). "Water Quality Impacts of Conservation and Nutrients Management Practices in Pennsylvania." Journal of Soil and Water Conservation; 49 (1) 59-66.

Haugland, R.A. (2007) Comparison of Enterococcus measurements in freshwater at two recreational beaches by quantitative polymerase chain reaction and membrane filter culture analysis. Water Resource 39 (4): 559–568

Hausman, J. (2012) Contingent valuation: from dubious to hopeless. Journal of Economic Perspectives, 26 (4), 43-56.

Heimlich, R.E., Wiebe, K.D., Claassen, R., Gadsby, D., and House, R.M. (1998). Wetlands and Agriculture: private interest and public benefits. USDA, Economic Research Service, Agriculture Economic Report Number 765

Herdt, R.W., and Steiner R.A. (1995). Agricultural sustainability: concepts and conundrums. In: Barnett V, Steiner R (eds) Agricultural sustainability: economic, environmental and social considerations. Wiley, Chichester/New York/Brisbane/Toronto/Singapore, 257

Hilliard, C., and Reedyk, S. (2003). Agricultural Best Management Practices. Agriculture and Agri-Food Canada. Ottawa.

Hilliard, C., Scott, N., Lessa, A., and Reedyk, S. (2002).Agricultural Best Management Practices
for the Canadian prairies: A review of literature, Canada-Saskatchewan Agri-Food Innovation Fund. File No.: 6672-1-12-1-18

Hoehn, R.C. (2002). Understanding and Controlling the Taste and Odor of Drinking Water. AWWA Annual Conference, New Orleans.

Holt, C.A., and Laury, S.K. (2002). Risk aversion and incentive effects. The American Economic Review 92(5): 1644-1655.

Hope, J.D., Brook Harker, D.B., and Townley-Smith, L. (2002). 'Long Term Land Use Trends for Water Quality Protection' Journal for Geophysical Research, 18(1), 53-58.

Hovde, B., and Leitch, J.A. (1994). "Valuing prairie potholes: five case studies" Agricultural Economics Report No. 319. Department of Agricultural Economics, Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota 58105.

Howarth, R.W. (2003). Coastal nitrogen pollution: Toward a national strategy for the US. Paper presented at the American Society of Limnograpy and Oceanography Aquatic Sciences Meeting; 8–14 February 2003, Salt Lake City, Utah

Hrudey S.E., Rector, D. and Motkosky, N. (1992) Characterization of drinking water odour arising from spring thaw for an ice-covered upland river source. Water, Science and Technology 25, 65-72.

Hull, A., Tricker, R., Forrester, J., and Snell, C. (2007). Understanding the processes of policy delivery for sustainable urban transport. DISTILLATE deliverable D1.

Johnson, K.N., Franklin, J.F., Thomas, J.W. and Gordon, J. (1991). Alternatives for management of late-successional forests of the Pacific Northwest. A report to the Agriculture Committee and the Merchant Marine Committee of the U.S. House of Representatives. 59.

Johnson, P.M. (2003). A Glossary of Political Economy. Institute for Socio-Economic and Political Studies, Penerbit TERAJU,Jakarta,Indonesia.http://www.auburn.edu/~johnspm/gloss/externality. Retrieved June 07, 2016

Kirk, J.T.O. (1994). Light and Photosynthesis in Aquatic Ecosystems. (2nd Ed). Cambridge University Press, New York, New York. 509 pp.

Kwadzo, T-M.G., Kuwornu, J.K.M., and Amadu, I.S.B. (2013). Food Crop Farmers' Willingness to Participate in Market-Based Crop Insurance Scheme: Evidence from Ghana. Research in Applied Economics 5(1):1-21. ISSN 1948-5433.

Leung, S.F., and Yu, S. (2000). 'Collinearity and Two Step Estimation of Sample Selection Models: Problems, Origins, and Remedies', Computational Economics.15, 173–199

Li, S., Elliott J.A., Tiessen, K.H.D, Yarotski, J., Lobb, D.A., and Flaten, D.N. (2011). The Effects of Multiple Beneficial Management Practices on Hydrology and nutrients Losses in a small watershed in Canadian Prairies. Journal of Environmental Quality. 40:1627–1642.

Lichtenberg, E. (2000). Agriculture and the environment. Handbook of Agricultural Economics. Working paper No. 00-15 http://ageconsearch.umn.edu/bitstream/285671/1/wp00-15pdf

Limburg, K.E., O'Neil, R.V. Costanza, R., and Farber, S. (2002).Complex systems and valuation. Ecological Economics 41,409–420

Lindner, J.R., Murphy, T.H., and Briers, G.E. (2001). Handling nonresponse in social science research. Journal of Agricultural Education, 40(6), 43-53.

Long, Q.T., Minh, T.B., Manh, C.N., and Thanh, T.V. (2013). Farm Households' Willingness to Pay for Crop (micro) insurance in Rural Vietnam: An Investigation Using Contingent Valuation Method. East Asian Development Network (EADN) Working Paper No.64.

Loomis, J., and Ekstrand, E. (1997). Economic Benefits of Critical Habitat for the Mexican Spotted Owl: A Scope Test Using a Multiple-Bounded Contingent Valuation Survey. Journal of Agricultural and Resource Economics. 22(2):356-366.

Lovell, S.T. and Sullivan, W.C. (2006). Environmental benefits of conservation buffers in the United States: evidence, promise, and open questions. Agriculture Ecosystems and Environment, 112 (2006), 249–260

Lubell, M., Schneider, M., Scholz, J.T., and Mete, M. (2002). Watershed Partnerships and the Emergence of Collective Action Institutions. American Journal of Political Science 46(1): 48-163

Maloney, K.O. Mulholland, P.J. and Feminella, J.W. (2005) Influence of catchment-scale military land use on physicochemical conditions in small Southeastern Plains streams (USA).Journal of Environmental Management, 35 (2005), 677–691

Matthiessen, P., Allchin, R.J., Williams, R.J., Bird, S.C., Brooke, D., and Glendinning, P.J. (1992). The translocation of some herbicides between soil and water in a small catchment. Journal of the Institution of Water & Environmental Management 6, 496–504.

McRae, T., Smith, C. A. S., and Gregorich, L. S. (2000). Environmental sustainability of Canadian agriculture: Report of the agri-environmental indicator project. A summary. (No. 1). Ottawa, Ontario: Agriculture and Agri-Food Canada

Michalyna, W., Prodalsky, G., and Jacques, E.S. (1988). Soils of the Rural Municipalities of Grey, Dufferin, Roland, Thompson and part of Stanley, 1988. Canada-Manitoba Soil Survey. Report D60

Miller, L.E., and Smith, K. (1983). Handling non-response issues. Journal of Extension On-line, 21(5). Available at: http://www.joe.org/joe/1983september/83-5-a7.pdf

Misra, S.K., Huang, C.L., and Ott, S.L. (1991). ‘‘Consumer Willingness to Pay for Pesticide-Free Fresh Produce.’’ Western Journal of Agricultural Economics 16 (Dec.): 218–27.

Mitchell, R.C., and Carson, R.T. (1981). An Experiment in Determining Willingness to Pay for National Water Quality Improvements. Draft report to the US Environmental Protection Agency, Washington DC.

Mitchell, R.C., and Carson, R.T. (1984). A Contingent Valuation Estimate of National Freshwater Benefits. Technical Report to the US Environmental Protection Agency (Washington, DC, Resources for the Future).

Naiman R.J, Decamps H., and Pollock, M. (1993). The role of riparian corridors in maintaining regional biodiversity. Ecological Applications, 3: 209-212

Nimoh, F., Baah, K., and Tham-Agyekum, E.K. (2011). Investigating the Interest of Farmers and Insurance Companies in Farm Insurance: The Case of Cocoa Farmers in Sekyere West Municipal of Ghana. Journal of Agricultural Science 3(4): 126-135.

Osbandi, K., and Green, E.J. (1991). A revealed preference theory for expected utility. The Review of Economic Studies, 58(4): 677–695. Retrieved June 24, 2016.

Parks, S., and Gowdy, J. (2013). What have economist learned about valuing the nature? A review essay. Ecosystem Services. www.elsevier.com/locate/ecoser. Retrieved March 17, 2016.

Poterba, J.M. (1996). "Government Intervention in the Markets for Education and Health Care: How and Why?" In Victor R. Fuchs. Individual and Social Responsibility: Child Care, Education, Medical Care and Long-Term Care in America. Chicago: University of Chicago Press: 277-304

Pease, J. (1998). Economic and Environmental Impacts of Nutrient Loss Reduction on Dairy and Dairy/Poultry Farms. Virginia Cooperation Extension Publication 448-231/REAP R033

Roberts, L.A., and Leitch, J. (1997). Economic Valuation of Some Wetland Outputs of Mud Lake Minnesota-South Dakota." Agricultural Economics Report No. 381, Department of Agricultural Economics, North Dakota State University, Fargo, 1997

Roth N.E., Allan J.D., Erickson D.L. (1996). Landscape influences on stream biotic integrity assessed at multiple spatial scales. The Journal of Landscape Ecology, 11, 141-56

Schwepker, C.H.J., and Cornwell, T.B. (1991). An Examination of Ecologically Concerned Consumers and Their Intention to Purchase Ecologically Packaged Products. Journal of Public Policy and Marketing 10 (fall): 77–101

Sharpley, A., Smith, S.J., Zollweg, J.A., and Coleman, G.A. (1996). Gully treatment and water quality in the Southern Plains. Journal of Soil and Water Conservation 51(6):498-503.

Sharpley, A.N., and Rekolainen, S. (1997). Phosphorus in agriculture and its environmental implications. In Phosphorus Loss from Soil to Water. H. Tunney, O.T. Carton, P.C. Brookes, and A.E. Johnston, 1–53. New York: Center for Agriculture and Biosciences International, ISBN0-85199-156-4

Shultz, A.D., and Leitch. J.A. (2001). The feasibility of wetland restoration to reduce flooding in the Red River Valley: A case study of the Maple River Watershed, North Dakota. Agribusiness &Applied Economics Report No. 432a. Department of

Agribusiness and Applied Economics, Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota 58105-5636

Shultz, S., Pinazzo, J., and Cifuentes, M. (1998). Opportunities and limitations of contingent valuation surveys to determine national park entrance fees: evidence from Costa Rica. Environment and Development Economics, 3; 131-149

Skinner J.A., Lewis K.A., Bardon K.S., Tucker P., Catt J.A., and Chambers B.J., (1997). An overview of the environmental impact of agriculture in the U.K. Journal of Environmental Management, 50:111-2

Smith, D.G., Cragg, A.M and Croker, G.F. (1991). Water Clarity Criteria for Bathing Waters Based on User Perception. Journal of Environmental Management, 33:285-299.

Smith, D.G. and Davies-Colley, R.J. (1992). Perception of Water Clarity and Colour in Terms of Suitability for Recreational Use. Journal of Environmental Management, 36:225-235.

Smith, E.G., Peters, T.L., Blackshaw, R.E., Lindwall, C.W., and Larney, F.J. (1996). Economics of reduced tillage fallow-crop systems in the Dark Brown soil zone of Alberta. Canadian Journal of Plant Science, 76, 411-416.

Smith, K.L., Fletcher, C.G. and Kushner, P.J. (2011). The role of linear interference in Northern Annular Mode variability associated with Eurasian snow cover extent. Journal of Climate, 24, 6185-6202

Sponseller R.A., Benfield, E.F., and Valett, H.M. (2001). Relationships between land use, spatial scale and stream macroinvertebrate communities. Freshwater Biology 46:1409-1424

Statistics Canada. (2011). Snapshot of Canadian agriculture.http://www.statcan.gc.ca/ca-ra2006/articles/snapshot-portrait-eng.htm#3. Reviewed: November 02, 2016

Statistics Canada. (2016). 2006 Agricultural Community Profiles http://www26.statcan.ca:8080/AgrProfiles/cp06/Table1.action?prov=47&search=search&placename=stdenis&placestart=0&geog_id=478115014&geog_id_amal=478115014&loccode=27086&tab_id=1http://www26.statcan.ca:8080/AgrProfiles/cp06/Table1.action?prov. Reviewed: August 07, 2016

Stoneham, G., Chaudri V., Ha, A. and Strappazon, L. (2003). Auctions for conservation contracts: an empirical examination of Victoria's Bush Tender trial. Australian Journal of Agricultural and Resource Economics, 47 (4), 477-500.

Stonehouse, D.P. (2000). Education experience with environmental farm plan in a case-study setting. The Journal of Agricultural Education and Extension, 7 (1) (2000), 1–9

Stonehouse, S.D. (1997). Socio-economics of alternative tillage systems. Soil and Tillage Research, 43(1-2), 109-130.

Stonehouse, D.P., and Bohl, M.J. (1990). Land degradation issues in Canadian agriculture. Canadian Public Policy, 14(4):418-431

Strutz, T. (2010). Data fitting and Uncertainty A practical introduction to weighted least squares and beyond. SpringerVieweg, October, 2010, 1st Edition, ISBN-13: 978-3-658-11455-8

Swinton, S.M., Lupi, F., Robertson, G.P., and Hamilton, S.K. (2007). Ecosystem services and agriculture: Cultivating agricultural ecosystems for diverse benefits. Ecological Economics, 64, 245-252.

Thomsen, J., Kulshreshtha, S., Lobb, D., Flaten, D., and MacDonald, K.B. (2010). “Agricultural Beneficial Management Practices for Lake Winnipeg – Cost-benefit analysis using an ecological goods and services approach.” The Thomsen Corporation, Project No. K1A12-09-0180

Tiessen, K.H.D., Elliott, J.A, Yarotski, J., Lobb, D.A., Flaten, D.N., and Glozier. N.E. (2010). Conventional and conservation tillage: Influence on seasonal runoff, sediment, and nutrient losses in the Canadian Prairies. Journal of Environmental Quality, 39:964-980.

Tiessen, K.H.D., Elliott, J.A., Stainton, M., Yarotski, J., Flaten, D.N., and Lobb, D.A. (2011). The effectiveness of small-scale headwater storage dams and reservoirs on stream water quality and quantity in the Canadian Prairies. Journal of Soil and Water Conservation, 66(3):158-171.Turner, B. 2011. Personal communications.

Tilman, D., Cassman, K.G., Matson, P.A., Naylor R. and Polasky, S. (2002). Agricultural sustainability and intensive production practices. Department of Ecology, Evolution and Behavior, and Department of Applied Economics, University of Minnesota, St Paul, Minnesota 55108, USA

Train, K.E. (2002). Discrete Choice Methods with Simulation. New York: Cambridge University Press.

Vella, F. (1998). ‘Estimating Models with Sample Selection Bias: A Survey’. The Journal of Human Resources 33(1): 127–169.

Wang L., Lyons J., Rasmussen P., and Seelbach, P. (2003). Watershed, reach, and riparian influences on stream fish assemblages in the Northern Lakes and Forest Ecoregion, U.S.A. Canadian Journal of Fish and Aquatic Science, 60:491-505

Wassenaar, L.I., Hendry, M.J. and Nikki, H. (2006). Decadal Geochemical and Isotopic Trends for Nitrate in a Trans boundary Aquifer and Implications for Agricultural Beneficial Management Practices. Environmental Science and Technology, 40(15), 4626–4632.

Whitten, S. (2003). Provision of environmental goods on private land: a case study of Australian wetlands. PhD thesis, School of Economics and Management, The University of New South Wales, Fremantle.

Wu, J.J., Zilberman, D. and Babcock, B.A (2001). Environmental and distributional impacts of conservation targeting strategies. Journal of Environmental Economics, 41, 333-350.

Wu, J.J., Zilberman, D., Babcock, B.A. and Lakshminarayan, P.G. (1997). Targeting tools for the purchase of environmental amenities. Land Economics, 73(3), 325-339.

Wu, J.J., Xu, L., and Groth, K.S. (2002). Targeting conservation efforts in the presence of threshold effects and ecosystem linkages. Ecological Economics, 42, 313-331.

Yarotski, J. (1996). Canada-Manitoba Soil Conservation Agreement, Program 6, South Tobacco Creek Pilot Project Effects of Headwater Storage on Runoff Peaks, Hydrology Report #142. PFRA/AAFC

.

APPENDIX A

Consent Form and Letter of Initial Contact

CONSENT FORM

Title of Project: Economic Analysis of beneficial management practices (BMPs) in Southern Manitoba

Investigators: Jonathan Mingle, Primary researcher **(Graduate student, BPBE, University of Saskatchewan) Tel: 306 491 4338**

Ken Belcher, Co-Supervisor **(Professor, BPBE, University of Saskatchewan**
Tel: 306 966-4019

Mohammad Khakbazan, Co supervisor **(Agriculture and Agri-Food Canada)**
Tel: 204 578-6555

Purpose and Procedure: The purpose of this study is to estimate the value society places on changes in water quality and changes in flooding patterns around the South Tobacco Creek. The estimated time to complete the survey is 10-15 minutes. **This survey will be administered as a face to face interview or, if more convenient, a telephone interview will be used. In either case all responses will be recorded by the researcher on the paper questionnaire forms.**

Potential Benefits: Your participation will increase the understanding of values and benefits of agricultural beneficial management practices to individuals and communities located downstream from the areas where the beneficial management practices are used.

Potential Risks: There are no known risks associated with participating in the survey. All data will be stored in a safe and secure manner and all information will be confidential.

Storage of Data: The researcher will store all data collected in a safe and secure manner at the Department of Bioresource Policy, Business and Economics and with Agriculture and Agri-

Food Canada for a period of five years. The data will be destroyed, after 5 years, when it is no longer required.

Anonymity and Confidentiality: Anonymity will be maintained by ensuring that there are no individual identifiers attached to each completed survey form. The research results will be published in a variety of formats, both print and electronic. The survey process does not enable a link between respondent identity and responses. These materials may be further used for purposes of conference presentations, or publication in academic journals, books or popular press. In these publications, the data will be reported in a manner that protects confidentiality and the anonymity of participants. The information provided by survey participants will be used and presented in aggregate without individual responses being reported.

Right to Withdraw: Your participation is voluntary, and you can answer only those questions that you are comfortable with. The information that is shared will be held in strict confidence and discussed only with the research team. You may withdraw from the research project for any reason, at any time during the survey answering process, without penalty of any sort. If you withdraw from the research project, any data that you have contributed will be destroyed at your request. However, after the survey is completed, you may not be able to withdraw due to the inability of identifying your survey

Additional contacts: If you have any questions concerning the research project, please feel free to ask at any point; you are also free to contact the researcher at the number provided if you have other questions (306 491 4338). **This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. Any questions regarding your rights as a participant may be addressed to that committee through the Research Ethics Office ethics.office@usask.ca (306) 966-2975. Out of town participants may call toll free (888) 966-2975.**

Consent to Participate: I understood the description provided; I have had an opportunity to ask questions and my/our questions have been answered. I consent to participate in the research project, understanding that I may withdraw my consent at any time. I will receive a copy of this consent form after I sign it.

Oral Consent

I read and explained this Consent Form to the participant before receiving the participant's consent, and the participant had knowledge of its contents and appeared to understand it.

______________________	______________________	____________
Name of Participant	**Researcher's Signature**	**Date**

LETTER OF INITIAL CONTACT

51 Campus Drive

Bioresource Policy, Business and Economics

S7N 5A8, Saskatoon

15th December, 2015

Dear Sir/ Madam,

I am a graduate student in the Department of Bioresource Policy, Business and Economics at the University of Saskatchewan. As part of my master's degree I am doing research in the area of the Tobacco Creek in Manitoba. I am interested in the values that people assign to improvements in water quality and changes in flooding that can occur as a result of farmers adopting different agricultural management practices. The research is on behalf of Agriculture and Agri-Food Canada and the University of Saskatchewan. The findings from my research will help the development of agricultural policy that can do a better job of addressing concerns about water quality and flooding while enabling farmers to continue to produce important food products.

I would like to talk to you about being a participant in this research project. If you are willing I would like to talk with you and complete a short 10 minute survey where I will ask you about your values related to changes in water quality and flooding in and around Tobacco Creek. All survey information will be kept confidential.

I will contact you soon to talk about this project and to see if you would be willing to participate in this survey. Thank you in advance for considering this request.

Yours Sincerely,

Jonathan Mingle.

(Primary Researcher)

APPENDIX B

Survey Questionnaire Package

ECONOMIC ANALYSIS OF BENEFICIAL MANAGEMENT PRACTICES (BMPs) IN SOUTHERN MANITOBA

BACKGROUND

The purpose of this survey is to understand the benefits that may be provided when farms adopt various kinds of beneficial management practices (BMPs). BMPs are agricultural management practices designed to decrease the impact on the environment as compared to conventional practices. A range of BMPs have been adopted by producers including winter bale-grazing, holding ponds downstream of winter cattle containment areas, comparison of conservation and conventional tillage, small dams and reservoirs. The adoption of agricultural BMPs by producers can result in increased environmental benefits and/or decrease the negative environmental impacts from certain agricultural activities. For example, BMPs have been designed to decrease the frequency and/or severity of flooding, limit the erosion of sediment and nutrients into downstream surface water, improving or increasing recreational activity benefits. Understanding the effectiveness of these management practices to meet environmental objectives will help inform BMP-based policy development and adoption. In Canada, farmers have been encouraged to adopt BMPs through government payments that are designed to partially offset the costs of BMP adoption on their land. In this research I want to collect information to help me understand the values of these environmental changes to individuals and communities that are in close proximity to the agricultural areas where the BMPs have been adopted.

Thank you very much in advance for your time and valuable input.

SECTION 1

1. What is your status/position in or around the watershed?

(a) Farmer (b) Rural resident

If you are a farmer answer questions 2 to 5

2. What type of farm operation do you have?

(a) Grain

(b) Mixed grain & Cattle (approximate proportion of farm income in an average year),

Grain ……………. %

Cattle……………%

(c) Other (Specify)………………………….

3. What is the make-up of the land that you farm?

a) Annual cropland ……………acres

b) Hay and pasture ……………acres

4. Have you adopted any BMPs on the land that you farm?

(a) No (b) Yes

5. If you have adopted BMPs have you received any financial assistance to offset the cost of implementing BMPs?

(a) No

(b) Yes, from a government agency

(c) Yes, from a private agency

(d) Yes, from other, specify…………………………………..

In this next section you will be presented with different types of environmental characteristics that can be influenced by the adoption of BMPS. These environmental characteristics are categorized at different levels which will be used to measure how you value changes in environmental quality in the local creeks and rivers.

Attribute	Levels
Water Clarity	Very murky (cannot see submerged objects) Moderately clear (can see objects up to 2 inches under water) Clear (can see objects 12 inches under water)
Water Odour	Odour throughout the ice-free season Odour during July and August only No odour
Water Quantity	Flooding occurs every 1.5years Flood discharge occurring every 5 years Flood discharge occurring once every 10years
Recreation and Fish Habitat	Limited recreation activity, swimming and fishing not recommended Fishing possible All recreation allowed with high quality

SECTION 2: Estimation of WTP

Please consider the following water quality and quantity scenarios within and around the local watershed (South Tobacco Creek) that can be influenced by the adoption of BMPs by farmers upstream. Assume that the farmers who adopt the BMPs will be at least partially compensated for the costs of BMP adoption by government payments that come from property tax revenues. You will be asked whether you would be willing to pay certain levels of increased annual taxes to cover the costs of BMP adoption by farmers in the South Tobacco Creek watershed. For each level of increased tax please indicate if you would be willing to definitely pay, probably pay, probably not pay, or definitely not pay the tax increase to compensate farmers to adopt BMPs which provide the following benefits.

2.1 WATER CLARITY in South Tobacco Creek

How would you feel about the following proposed increase in annual taxes to increase water clarity from **murky to moderately clear**?

Amount	Definitely not pay	Probably not pay	Probably pay	Definitely pay
greater than$100/year				
$100/year				
$90/year				
$80/year				
$70/year				
$60/year				
$50/year				
$40/year				
$30/year				
$20/year				
$10/year				
$0/year				

How would you feel about the following proposed increase in annual taxes to increase water clarity from **moderately clear to very clear**

Amount	Definitely not pay	Probably not pay	Probably pay	Definitely pay
greater than $100/year				
$100/year				
$90/year				
$80/year				
$70/year				
$60/year				
$50/year				
$40/year				
$30/year				
$20/year				
$10/year				
$0/year				

2.2 WATER ODOUR in South Tobacco Creek

How would you feel about the following proposed increase in annual taxes to decrease water odour from **throughout the ice free season** to **odour during only the warmest months of the year**, July and August?

Amount	Definitely not pay	Probably not pay	Probably pay	Definitely pay
greater than $100/year				
$100/year				
$90/year				
$80/year				
$70/year				
$60/year				
$50/year				
$40/year				
$30/year				
$20/year				
$10/year				
$0/year				

How would you feel about the following proposed increase in annual taxes to decrease water odour from **being present during only during July and August** (warmest months of the year) to the **water having no odour**?

Amount	Definitely not pay	Probably not pay	Probably pay	Definitely pay
greater than $100/year				
$100/year				
$90/year				
$80/year				
$70/year				
$60/year				
$50/year				
$40/year				
$30/year				
$20/year				
$10/year				
$0/year				

2.3 WATER QUANTITY in South Tobacco Creek

How would you feel about the following proposed increase in annual taxes to **decrease flooding frequency and duration from every year to once every 5 years**?

Amount	Definitely not pay	Probably not pay	Probably pay	Definitely pay
greater than $100/year				
$100/year				
$90/year				
$80/year				
$70/year				
$60/year				
$50/year				
$40/year				
$30/year				
$20/year				
$10/year				
$0/year				

How would you feel about the following proposed increased annual taxes to **decrease flooding frequency and duration from once every 5 years to once every 10 years?**

Amount	Definitely not pay	Probably not pay	Probably pay	Definitely pay
greater than $100/year				
$100/year				
$90/year				
$80/year				
$70/year				
$60/year				
$50/year				
$40/year				
$30/year				
$20/year				
$10/year				
$0/year				

2.4 RECREATION & FISH HABITAT in Tobacco Creek

How would you feel about the following proposed increase in annual taxes to improve water-related recreation opportunities and fish/wildlife habitat such that the creek **improved from a condition where swimming and fishing were not recommended** to a **condition where fishing was possible**?

Amount	Definitely not pay	Probably not pay	Probably pay	Definitely pay
greater than $100/year				
$100/year				
$90/year				
$80/year				
$70/year				
$60/year				
$50/year				
$40/year				
$30/year				
$20/year				
$10/year				
$0/year				

How would you feel about the following proposed increase in annual taxes to improve water-related recreation opportunities and fish/wildlife habitat such that the creek improved from a **condition where fishing was possible** to where **all recreational activities would be possible**?

Amount	Definitely not pay	Probably not pay	Probably pay	Definitely pay
greater than $100/year				
$100/year				
$90/year				
$80/year				
$70/year				
$60/year				
$50/year				
$40/year				
$30/year				
$20/year				
$10/year				
$0/year				

THIS THIRD SECTION ASKS SOME QUESTIONS ABOUT SOME OF YOUR RESPONSES AND THOUGHTS DURING THE LAST SECTION

(1) Consider your responses to the previous 8 questions. Are you satisfied that the response you gave accurately reflects your attitudes about changes in water quality and quantity. In the following questions indicate how sure you are about your response to each of the previous 8 questions using a 100 point scale, where 100 indicates you are most sure about your response and 0 indicates you are least sure about your response:

Water clarity

0 10 20 30 40 50 60 70 80 90 100

If you are not sure at all, please indicate why?

………

Water odour

0 10 20 30 40 50 60 70 80 90 100

If you are not sure at all, please indicate why?

………

Water quantity

0 10 20 30 40 50 60 70 80 90
100

If you are not sure at all, please indicate why?

………

Recreation and Fish Habitat

0 10 20 30 40 50 60 70 80 90
100

If you are not sure at all, please indicate why?

………

(2)If you chose $0.00 for any of the questions in section 2, which statements best explain your answer. Check as many that apply)

…….. I am not familiar with BMPs

……... I do not value any benefit provided by any BMP

……... The watershed is far from my home

……...Other reasons (please state)………..………………………………………………

Section 4: ABOUT YOU

1. What is your gender?

(a) Male

(b) Female

2. How old are you?

(a) 18-24 years (b) 25- 44years (c) 45-60years (d) greater than 60 years

3. Which best describes your home area?

(a) Rural, non-farm (b) Farm (c) Urban

4. Approximately how far is the one way distance to South tobacco creek from your home? ....Km

5. What is the highest grade in school that you have completed?

(a) Some formal schooling

(b) High school diploma or GED

(c) Some college

(d) 2 year university or college degree

(e) 4 year university degree

6. What was your approximate total household income last year?

(a) Less than $24,999

(b) $25,000 to $49,999

(c) $50,000 to $74,999

(d) $75,000 to $99,999

(e) $100,000 or more

If you have any additional comments please feel to provide them in the comments section on the back of this page

APPENDIX C

ECONOMETRIC MODELS (STC sample)

Table 1: WTP for water clarity in STC

Variable	Heckman Selection Model WC1(From murky to moderately clear) Probit model	OLS model	Heckman Selection Model WC2(From moderately clear to clear) Probit model	OLS model
Constant	2.413	49.297	4.376	36.679
	(2.178)	(74.075)	(2.734)	(93.859)
Educ2	-0.497	29.28*	-0.747	23.093
	(1.274)	(67.65)	(1.311)	(59.848)
Educ3	-0.639	22.44	-0.542	54.321
	(1.498)	(60.753)	(1.335)	(40.896)
Educ4	-0.351	45.643	0.066	61.130
	(1.421)	(45.582)	(1.485)	(44.821)
Educ5	-0.730	61.644	-1.219	41.781
	(1.295)	(62.784)	(1.353)	(60.587
Gender1	-0.432	-15.871	-1.039	-25.375
	(0.615)	(39.441)	(0.716)	(42.912)
Y(25000-49999)	-0.603	-0.113	-1.420	20.778
	(1.269)	(53.463)	(1.566)	(54.154)
Y(50000-74999)	0.167	13.330	-0.396	-19.506
	(0.907)	(50.774)	(1.102)	(26.248)
Y(75000-99999)	1.053	-22.573	-0.579	78.931*
	(1.552)	(107.291)	(1.852)	(39.971)
Y(100000above)	0.394	-7.368	1.879	-2.923
	(1.389)	(82.864)	(2.076)	(90.279)
Age(45-59)	-1.331	-12.671	-1.567	13.408
	(1.158)	(110.540)	(1.589)	(67.081)
Age(60 above)	-1.386	-31.879	-2.354*	-34.259
	(1.832)	(125.106)	(1.832)	(111.505)
HomeArea2	-1.018	-10.111	-0.747	-21.916
	(1.094)	(28.220)	(1.152)	(28.405)
HomeArea3	0.370	-40.005*	-0.277	-79.386*
	(1.080)	(51.692)	(1.371)	(90.462)
Mills Ratio		17.945		30.533
		(195.303)		(114.534)
Observations	30	21	30	22
R^2		0.578		0.731
Adjusted R^2		-0.407		0.193
Log Likelihood	-15.103		-5.521	
F-Statistics		0.587(df=14, 6)		1.358 (df=14,9)

Note: Robust standard errors *p<0.1, **p<0.05, ***p<0.01

Table 2: WTP for decreased water odour in STC

Variable	Heckman Selection Model WO1(Odour through-out the ice season to odour in July and August) Probit model	OLS model	Heckman Selection Model WO2(Odour through July and August to No odour) Probit model	OLS model
Constant	1.121	-112.224		36.679
	(2.364)	(167.335)		(93.859)
Educ2	-2.349		-1.782	
	(1.570)		(1.501)	
Educ3	-1.224	24.534	1.516	184.663
	(1.460)	(150.127)	(1.495)	(143.506)
Educ4	0.330	147.346	-0.921	69.704
	(1.665)	(124.953)	(0.677)	(139.724)
Educ5	-1.040	30.888	-1.763	202.182
	(1.398)	(120.446)	(1.398)	(162.078)
Gender	-0.476	32.690	-0.324	17.912
	(0.708)	(60.991)	(0.677)	(29.571)
Y(25000-49999)	-0.587	-32.411	-1.958	200.625
	(1.402)	(81.265)	(1.565)	(190.113)
Y(50000-74999)	-0.587	-15.837	0.252	-27.489
	(1.402)	(31.525)	(1.111)	(31.149)
Y(75000-99999)	-1.760		-0.794	14.891
	(1.823)		(1.724)	(100.477)
Y(100000above)	0.394	22.706	-0.461	39.784
	(1.389)	(67.155)	(1.744)	(42.405)
Age(45-59)	-0.458	-4.496	-1.478	103.556
	(1.396)	(49.122)	(1.363)	(105.436)
Age(60 above)	-2.158	-160.026	-2.615*	239.175
	(1.596)	(250.044)	(1.475)	(425.683)
HomeArea2	1.099	61.150	-0.758	57.085
	(0.987)	(149.169)	(0.973)	(77.627)
HomeArea3	0.571	21.430	-0.123	-43.911
	(1.399)	(137.391)	(1.248)	(81.616
Mills Ratio		17.945		-221.679
		(195.303)		(327.186)
Observations	30	16		19
R^2		0.617		0.684
Adjusted R^2		-0.916		-0.137
Log Likelihood	-7.736		-8.880	
F-Statistics		41.290(df=13, 5)		0.833 (df=13,5)

Table 3: WTP for reduced flooding in STC

Variable	Heckman Selection Model WQ1(From every 1.5yrs to 5yrs) Probit model	OLS model	Heckman Selection Model WQ2(From every 5yrs to 10yrs) Probit model	OLS model
Constant	4.307	-27.183	4.948*	-47.855
	(2.715)	(72.663)	(2.868)	(79.165)
Educ2	-0.673	102.527	-1.108	92.716
	(1.353)	(89.502)	(1.520)	(97.512)
Educ3	-0.006	69.205	-0.885	77.908**
	(1.498)	(38.808)	(1.513)	(18.16)
Educ4	0.532	-0.567	1.560	25.463
	(1.688)	(48.340)	(1.892)	(52.666)
Educ5	-1.490*	61.644	-0.603	83.566
	(1.465)	(62.784)	(1.377)	(68.403
Gender	-0.878	30.483	-1.256*	28.636
	(0.801)	(37.308)	(0.705)	(40.647)
Y(25000-49999)	-1.050	87.453	-2.722	87.008
	(1.566)	(47.967)	(1.669)	(52.260)
Y(50000-74999)	0.609	13.451	-1.174	20.800
	(1.311)	(33.760)	(1.190)	(36.971)
Y(75000-99999)	-0.149	52.214	-2.049	78.931*
	(1.852)	(36.688)	(1.917)	(39.971)
Y(100000 above)	1.879*	-6.937	0.111	-2.923
	(2.076)	(82.864)	(1.884)	(90.279)
Age(45-59)	-1.567	0.149	-0.890	13.408
	(1.589)	(61.571)	(1.379)	(67.081)
Age(60 above)	-2.677	-37.893	-2.071	29.648
	(1.832)	(30.575)	(1.549)	(112.559)
Homerea2	-1.018	23.800	-1.402	14.240
	(1.094)	(44.903)	(1.146)	(48.992)
HomeArea3	-2.007	48.143	-2.616	31.078
	(1.371)	(83.031)	(1.654)	(90.462)
Mills Ratio		2.114**		-112.533
		(60.207)		(228.271)
Observations	30	24	30	24
R^2		0.617		0.603
Adjusted R^2		0.022		0.013
Log Likelihood	-5.521		-5.521	
F-Statistics		1.038*(df=14, 9)		0.978(df=14,9)

Note: Robust standard errors *p<0.1, **p<0.05, ***p<0.01

Table 4: WTP for increase in recreation and fish habitat in STC

Variable	Heckman Selection Model RF1(Fishing not recommended to Fishing possible)		Heckman Selection Model RF2(Fishing possible to All recreation activities allowed)	
	Probit model	OLS model	Probit model	OLS model
Constant	4.984*	-2.892	4.984*	36.620
	(2.862)	(74.893)	(2.862)	(74.571)
Educ2	-1.108		-1.108	
	(1.520)		(1.520)	
Educ3	-0.885	-22.329	-0.885	-30.251
	(1.513)	(50.550)	(1.513)	(50.333)
Educ4	1.560	-31.104	1.560	28.563
	(1.892)	(44.919)	(1.892)	(44.726)
Educ5	-0.603	-55.876	-0.603	-57.840
	(1.377)	(50.752)	(1.377)	(50.534)
Gender	1.256*	8.237	1.256*	-16.107
	(10.750)	(33.447)	(10.750)	(33.303)
Y(25000-49999)	-2.722	(127.489	-2.722	68.482
	(1.917)	(74.571)	(1.917)	(62.754)
Y(50000-74999)	-1.174	16.425	-1.174	-11.550
	(1.190)	(30.368)	(1.190)	(30.238)
Y(75000-99999)	-2.049	50.430	-2.049	20.090
	(1.197)	(35.851)	(1.197)	(35.69)
Y(100000 above)	0.111	40.788*	0.111	45.130**
	(1.884)	(17.491)	(1.884)	(17.416)
Age(45-59)	-0.890	46.210	-0.890	21.790
	(1.379)	(26.482)	(1.379)	(26.368)
Age(60 above)	-2.071	22.509	-2.071	-27.558
	(1.549)	(46.274)	(1.549)	(46.075)
Homerea2	-1.402	76.223**	-1.402	56.340*
	(1.146)	(17.756)	(1.146)	(25.203)
HomeArea3	-2.616	54.687	-2.616	8.045
	(1.654)	(46.452)	(1.654)	(46.253)
Mills Ratio		172.554*		-83.954
		(60.207)		(71.132)
Observations	30	19	30	19
R^2		0.918		0.914
Adjusted R^2		0.706		0.692
Log Likelihood	-6.229		-6.229	
F-Statistics		4.319*(df=11,31)		4.105*(df=13,5)

Note: Robust standard errors *p<0.1, **p<0.05, ***p<0.01

APPENDIX D

ECONOMETRIC MODELS (Ag Days)

Table 5: WTP for increase water clarity at Ag Days

	Heckman Selection Model		Heckman Selection Model	
	WC1(murky to moderately clear)		WC2(moderately clear to clear)	
Variable	Probit model	OLS model	Probit model	OLS model
Constant	-1.327	0.657	-1.646	-5.733
	(1.525)	(39.46)	(1.567)	(37.73)
Educ4	0.263	31.609*	0.608	30.786*
	(1.279)	(16.75)	(1.245)	(16.78)
Educ5	-0.374	2.867	-0.139	1.509
	(1.057)	(18.49)	(1.063)	(18.16)
Gender	0.032		-0.057	
	(0.685)		(0.684)	
Y(25000-49999)	1.263		1.058	
	(1.261)		(1.298)	
Y(50000-74999)	0.747	12.202	0.611	19.388
	(1.226)	(17.06)	(1.240)	(15.22)
Y(75000-99999)	2.015	0.812	1.405	1.227
	(1.332)	(18.96)	(1.297)	(18.96)
Y(100000above)	2.022	21.344	1.976	21.794
	(1.332)	(21.31)	(1.346)	(20.01)
Age(45-60)	0.830	-20.915	0.834	-11.880
	(0.910)	(21.261)	(0.899)	(19.19)
Age(60 above)	1.898	-22.413	2.317*	-11.740
	(1.228)	(30.575)	(1.301)	(27.96)
Homerea2	0.622	40.596**	1.125	42.055**
	(1.149)	(17.756)	(1.143)	(20.24)
HomeArea3	0.768	29.287*	1.316*	35.776*
	(0.708)	(15.201)	(0.745)	(17.54)
Mills Ratio		2.114**		0.144
		(60.207)		(50.22)
Observations	52	43	52	36
R^2		0.424		0.310
Adjusted R^2		0.220		0.129
Log Likelihood	-10.476		-6.128	
F-Statistics		2.075**(df=11,31)		0.982(df=11,31)

Note: Robust standard errors *p<0.1, **p<0.05, ***p<0.01

Table 6: WTP for decrease water odour at Ag Days

Variable	Heckman Selection Model WO1(Odour through-out the ice season to odour in July and August)		Heckman Selection Model WO2(Odour through July and August to No odour)	
	Probit model	OLS model	Probit model	OLS model
Constant	-0.472	-103.551	-0.181	36.679
	(91.230)	(31.212)	(1.581)	(56.508)
Educ4	-0.947	-79.058	-1.201	31.835*
	(75.603)	(0.860)	(0.978)	(16.959)
Educ5	-0.053	20.847	-0.145	202.182
	(19.163)	(0.720)	(0.915)	(162.078)
Gender	-0.181		-0.550	
	(0.622)		(0.736)	
Y(25000-49999)	0.657		1.122	
	(1.231)		(1.309)	
Y(50000-74999)	0.848	45.317	0.469	-5.197
	(20.481)	(31.356)	(1.242)	(25.750)
Y(75000-99999)	1.554	98.793	2.253	-17.335
	(1.823)	(44.642)	(1.376)	(46.573)
Y(100000above)	1.396	84.694*	1.653	-13.104
	(1.246)	(47.475)	(1.330)	(43.021)
Age(45-59)	-0.579	-85.157	-0.135	-31.629
	(46.195)	(23.306)	(0.920)	(22.515)
Age(60 above)	0.707	5.376	0.954	-34.912
	(1.596)	(23.379)	(1.281)	(26.624)
HomeArea2	0.343	-8.183	-0.758	57.085
	(0.987)	(0.940)	(0.973)	(77.627)
HomeArea3	0.494	33.184	-0.123	12.249
	(1.373)	(0.625)	(1.248)	(15.662)
Mills Ratio		187.733		-42.310
		(51.209)		(327.186)
Observations	52	36	52	36
R^2		0.310		0.684
Adjusted R^2		-0.006		-0.137
Log Likelihood	-7.736		-8.880	
F-Statistics		0.982(df=11, 24)		0.829 (df=11,24)

Table 7: WTP for reduced flooding in Ag Days

Manitoba sample

Variable	Heckman Selection Model WQ1(From every 1.5yrs to 5yrs) Probit model	OLS model	Heckman Selection Model WQ2(From every 5yrs to 10yrs) Probit model	OLS model
Constant	-1.327	0.657	-3.029*	39.337
	(1.525)	(39.46)	(1.701)	(36.470)
Educ(2year degree)	-0.325	15.956	0.627	28.047
	(1.329)	(20.999)	(1.146)	(16.78)
Educ(4year degree)	-0.699	24.003	-0.502	30.355**
	(1.077)	(18.834)	(1.071)	(18.16)
Gender	0.577		0.991	
	(0.670)		(0.766)	
Y(25000-49999)	1.263		1.928	
	(1.268)		(1.288)	
Y(50000-74999)	2.547	44.964*	2.950*	28.309
	(1.226)	(17.06)	(1.240)	(22.751)
Y(75000-99999)	2.314*	40.900	2.964**	24.669
	(1.369)	(30.522)	(1.494)	(22.936)
Y(100000 above)	1.983	45.875	3.347**	38.719
	(1.329)	(27.252)	(1.526)	(24.859)
Age(45-59)	0.940	-34.516	0.781	-43.296**
	(0.959)	(26.069)	(0.926)	(19.631)
Age(60 above)	1.904	-34.324	2.317*	-60.328**
	(1.322)	(36.890)	(1.301)	(27.96)
HomeArea (Rural)	0.252	11.134*	1.125	6.916
	(1.131)	(19.014)	(1.143)	(15.729)
HomeArea(Urban)	0.466	-5.177	1.316*	-9.113
	(0.737)	(15.958)	(0.745)	(13.835)
Mills Ratio		62.930		7.333
		(74.332)		(43.864)
Observations	52	45	52	46
R^2		0.289		0.342
Adjusted R^2		0.052		0.129
Log Likelihood	-9.404		-9.404	
F-Statistics		1.219*(df=11,33)		1.606(df=11, 34)

Note: Robust standard errors *p<0.1, **p<0.05, ***p<0.01

Table 8: WTP for increase recreation and fish habitat at Ag Days

	Heckman Selection Model		Heckman Selection Model	
	RF1(Fishing not recommended to Fishing possible)		RF2(Fishing possible to All recreation activities allowed)	
Variable	Probit model	OLS model	Probit model	OLS model
Constant	-2.279	-51.936	-2.279	-18.403
	(1.424)	(37.43)	(1.424)	(37.73)
Educ4	-1.726	-27.925	-1.726	1.353
	(1.057)	(2.867)	(1.057)	(37.952)
Educ5	-0.029	32.034***	-0.029	36.763**
	(0.939)	(1.063)	(0.939)	(15.898)
Gender1	-0.527		-0.527	
	(0.685)		(0.685)	
Y(25000-49999)	3.128		3.128	
	(1.930)		(1.930)	
Y(50000-74999)	2.173	8.597	2.173	27.417
	(1.575)	(16.013)	(1.575)	(24.103)
Y(75000-99999)	1.954	-18.394	1.954	7.226
	(1.589)	(20.372)	(1.589)	(30.664)
Y(100000 above)	1.936	-36.088*	1.936	10.810
	(1.560)	(19.231)	(1.560)	(28.947)
Age(45-59)	0.807	7.316	0.807	-14.551
	(1.000)	(17.021)	(1.000)	(25.620)
Age(60 above)	1.448	18.422	1.448	-11.496
	(1.224)	(26.498)	(1.224)	(39.886)
Homerea2	1.199	38.147	1.199	38.038
	(1.019)	(25.270)	(1.019)	(20.24)
HomeArea3	1.147*	48.692*	1.147*	24.802
	(0.656)	(25.011)	(0.656)	(37.648)
Mills Ratio		130.441**		64.730
		(60.207)		(84.314)
Observations	52	434	52	44
R^2		0.612		0.353
Adjusted R^2		0.479		0.130
Log Likelihood	-9.484		-9.484	
F-Statistics		4.588**(df=11,32)		1.585(df=11,31)

Note: Robust standard errors *p<0.1, **p<0.05, ***p<0.01